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MDDC 1 **The Future of Atomic Energy, by *E. Fermi*. 14 p.**

There is definitely a technical possibility that atomic power may gradually develop into one of the principal sources of useful power. If this expectation will prove correct, great advantages can be expected to come from the fact that the weight of the fuel is almost negligible. This feature may be particularly valuable for making power available to regions of difficult access and far from deposits of coal. It also may prove a great asset in mobile power units for example in a power plant for ship propulsion. On the negative side there are some technical limitations to the applicability of atomic power of which perhaps the most serious is the impossibility of constructing light power units; also there will be some peculiar difficulties in operating atomic plants, as for example the necessity of handling highly radioactive substances which will necessitate, at least for some considerable period, the use of specially skilled personnel for the operation. But the chief obstacle in the way of developing atomic power, will be the difficulty of organizing a large scale industrial development in an internationally safe way. This presents actually problems much more difficult to solve than any of the technical developments that are necessary. It will require an unusual amount of statesmanship to balance properly the necessity of allaying the international suspicion that arises from withholding technical secrets, against the obvious danger of dumping the details of the procedures for an extremely dangerous new method of warfare on a world that may not yet be prepared to renounce war Furthermore, the proper balance should be found in the relatively short time that will elapse before the 'secrets' will naturally become open knowledge by rediscovery on part of the scientists and engineers of other countries.

MDDC 2 The Spatial Distribution of Neutrons Slowed Down By Elastic Collisions, by *G. Placzek*. 66 p.

Approximate treatment and its limitations: consider a neutron, born at the time t = 0 with velocity V = 1. At a later time, the neutron will have a velocity distribution F (v,t) $\frac{dv}{v}$, determined by the collisions that took place within this time. In the stationary case, to every velocity will correspond an age distribution and vice versa.

Age velocity distribution: let F (v,t) $\frac{dv}{v}$, be the velocity distribution for a neutron of age t, average over space. It has been shown that the time dependent neutron distributions without capture are the Laplace inversions of the stationary distributions with capture corresponding to a constant lifetime t. F(v,t) for the case of free nuclei initially at rest, and angular distribution isotropic in the center of gravity system are determined, limited to the case of constant mean free path.

A general scheme of treatment is based on the transport equation.

Fermi's one-dimensional model has been used where the motion of neutrons is in a straight line. By generalizing it is used for the illustration of the essential properties of the spatial distribution function in the case of scattering with energy change.

An asymptotic expression for the moment of the density is derived.

For an isotropic point source the distribution function depends only on the absolute value of the distance from the source and the cosine of the angle between the radius vector and the neutron direction vector. Calculations are carried out based on these assumptions.

A table of notations is appended.

MDDC 3 **The Slow Neutron Cross-Sections of Indium, Gold, Silver, Antimony, Lithium and Mercury as Measured with a Neutron Beam Spectrometer,** *W. W. Havens, Jr., J. Rainwater.* 59 p.

The variations of the slow neutron transmissions of In, Au, Ag, Sb, Li and Hg have been investigated as a function of the time of flight of the incident neutrons for a 5.4 meter path using a neutron beam spectrometer. A method of analysis is developed for determing E_o and $\sigma_o\Gamma^2$ for resonances above 1 ev based on the experimental transmission curves and the Breit-Wigner theory. The positions of the levels located, listed in order of importance for each element, are: -

In, 1.44 ± 0.04 ev; Au, 4.8 ± 0.2 ev; Ag, 5.11 ± 0.2 ev, 13.7 ± 1 ev, and 43 ± 5 ev; Sb, 6.3 ± 0.4 ev, 19.2 ± 1.0 ev and indications of other unresolved levels in the region of 50 to 500 ev, Li only a 1/v cross-section; Hg, a negative level at -2.0 ± 0.2 ev and indications of unresolved positive levels above 25 e v.

In the thermal region, the Ag, Sb and Li cross-section curves can be resolved into the sum of a constant term and a 1/v term. If E is the neutron energy in ev, these are:

Ag: $[(9.05 \pm 0.10)\ E^{-1/2} + (6.6 \pm 0.5)]$ barns

Sb: $[(0.64 \pm 0.02)\ E^{1/2} + (4.2 \pm 0.3)]$ barns

Li: $[(11.5 \pm 0.2)\ E^{-1/2} + (1.7 \pm 0.2)]$ barns

LiF was used in the Li measurements and a value 2.5 barns has been deducted for the F.

The Hg cross-section below 5 ev was well matched by the relation $(64 \pm 3)\ E^{-1/2}\left(1 + \frac{E}{2.0}\right)^2$ barns.

MDDC 4 **Neutron Beam Spectrometer Studies of Boron, Cadmium, and the Energy Distribution from Paraffin**, by *J. Rainwater, W. W. Havens, Jr.*. 50 p

A slow-neutron velocity selector has been developed for use with the Columbia University cyclotron By the method of arc modulation, neutron production is usually confined to intervals of (10-200) microseconds out of a 1000-10,000 microsecond cycle. Neutrons slowed down in paraffin are detected by BF_3 proportional counters. Excellent collimation is obtained by using an extensive B_4C and Cd collimating system. Experiments were conducted principally at a 5.4 meter source-detector distance.

A special selector system counts all the neutrons detected and also selectively counts those detected in an adjustable timed interval after the cyclotron burst.

The slow-neutron energy distributions from paraffin 'source' slabs were shown to be of a modified Maxwellian form with an assymmetrical high energy 'tail.'

Data for the resonance absorption by Cd were well matched by a one level Breit-Wigner formula having $E_o = (0.180 \pm 0\ 008)$ ev, $\Gamma = (0.112 \pm .006)$ ev, $\sigma_o = (7,8000 \pm 800)$ barns. The result of measurements with several boron filters over the range of 0.01 ev to over 100 ev were well matched by the 1/v relation, $\sigma_B = (118 \pm 4)\ E^{-1/2} \times 10^{-24}$ cm^2/atom

MDDC 5 **Mass Spectrometer for Leak Detection**, by *A. O. Nier C. M. Stevens, A. Hustrulid, T. A. Abbott*. 17 p.

A simple low resolution mass spectrometer is described which has been used successfully in detecting small leaks in high-vacuum equipment. One part of He in 200,000 parts of air can be detected.

MDDC 6 **The Neutron-Proton and Neutron-Carbon Scattering Cross-Sections for Fast Neutrons**, by *C. L. Bailey, W. E. Bennett.* 20 p.

An experimental investigation of the scattering cross-section of hydrogen and carbon for neutrons of energies 0.35 to 6.0 Mev is reported. Neutrons of discrete energies were produced by particle bombardment of lithium, carbon and heavy water targets. Transmissions of cyclohexane (C_6H_{12}) and graphite scatterers under conditions of good geometry were measured. Results of σ_s(H) were compared to the theoretical interpretations of Bohm and Richman and to the experimental results of D. Frisch at lower energies (MDDC-51). It is estimated that σ_s(H) and σ_s(C) are probably determined to five percent.

MDDC 7 **Thick Target Yields with Deuteron-Proton Reactions**, by *E. C. Barker.* 7 p.

Measurements of the amount of bombardment, including the deuteron energy and measurements of the amount of radioactivity were made. The deuteron beam emerging from a 0.001" thick aluminum window of the cyclotron was made to pass through a defining aperture before striking the target. Bombardments were always short compared with the half-life of the product isotope so that the effect of decay during activation could be neglected. The amount of radioactivity produced was measured with a thin window Lauritsen electroscope which was calibrated with a uranium X beta ray standard. The experimental yields in millicuries of product per microampere-hour of bombardment are shown by tables. Values for half lives and parent abundancies are those given by Seaborg.

MDDC 8 On The Disintegration of Nitrogen by Fast Neutrons, by *H. H. Barschall, M. E. Battat* 19 p.

The cross-sections of the N(n,p)C and N(n,α)B reactions were measured for neutrons of energies between 0.2 and 1.7 Mev Resonances were observed for neutron energies of 0.55 0.70 and 1.45 Mev.

The (n p) reaction shows resonances at 550, 700, and 1450 Kev. The (n,α) cross-section was measured at four neutron energies There is a definite indication that the (n α) process shows a resonance at the same energy as the (n,p) reaction. This is to be expected, since both processes result from the disintegration of the same compound nucleus. Values of the cross-sections may be in error by 25%.

MDDC 9 Scattering of Fast Neutrons by Boron, by *H H. Barschall, M. E. Battat.* 6 p.

The cross section of boron for the scattering of fast neutrons through angles greater than 30° was measured at neutron energies between 0 2 and 3 Mev In the present experiments the scattering of neutrons of energies from 0.2 to 3 Mev was investigated for the two boron isotopes Boron powder containing 53 percent B^{10} was used.

Neutron energy	Normal B	53% B^{10}	B^{11} (Calcd.)	B^{10} (Calcd.)
0.2	3.5	3 8	3.4	1.6
0.6	2.4	2 9	2.2	2 5
0.8	1.8	2.1	1 6	2.0
1.0	1.6	1 9	1 4	1 8
1.2	2.0	1 8	2.2	1 0
1.5	1.9	1.9	1.9	1.2
3	1.6	1 6	1 6	1.1

The average error is about 5% for experimental values and about 10% and 20% for calculated values for B^{11} and B^{10} respectively.

MDDC 10 Neutrons from C^{12} + D, by *W. E. Bennett, H. T. Richards.* 11 p.

Recoil protons in a cloud chamber have been used to measure the energy spectrum of the neutrons from $C^{12} + H^2$. The neutrons are found to be monochromatic when produced by 2 Mev deuterons. An accurate Q value of -0.27 ± 0.02 Mev is computed from the range of the recoil protons. This Q value gives a more accurate mass for N^{13}, namely 13.00990 ± 0.00005.

The neutrons from carbon bombarded by deuterons have been used as a monochromatic source of fast neutrons of variable energy. In the present experiment the energy spectrum of these neutrons has been measured to determine whether or not the neutrons from C^{12} are in fact monochromatic.

MDDC 11 On the Existence of a Resonance Absorption of Neutrons in Graphite, by *S. Bernstein.* 13 p.

The purpose of the experiment was to determine whether or not an appreciable resonance absorption exists in graphite. A Ra-Be photo-source was surrounded by an 11" radius graphite sphere. The sphere was surrounded by a 4" thick spherical graphite shell. The graphite shell was surrounded by a minimum of 13" of paraffin. The total number of neutrons emitted by the source was determined from the total number of neutrons absorbed as thermals in graphite and paraffin for the following three cases; sphere, shell, and paraffin in place; sphere removed, shell and paraffin in place; sphere and shell removed. The difference between these numbers is a measure of the number of neutrons absorbed in the graphite resonance region. The results indicate that if a resonance absorption exists in graphite, then at most 5% of all neutrons passing thru such a level would be absorbed by the 11" graphite sphere.

MDDC 12 Atoms and Nuclei, by *H. A. Bethe*. 26 p.

The article reports a non-technical explanation of chemical and nuclear physical theory. A historical pattern is followed, starting with the Greek philosophers and proceeding to modern chemistry beginning with the French chemist Lavoisier in the 18th century. Terms such as element, atom, molecule, oxygen, hydrogen, etc, are defined and used for further explanations of nuclear physics conceptions. Isotopes, nuclei, Einstein's theory, protons, neutrons, electrons, and related terms are identified and discussed. As a popularized history of fission it explains the splitting of the uranium atom, the transformation to plutonium, and mentions useful applications the fields of biology, medical, chemical and industrial research.

MDDC 13 The Theory of the Synchrotron, by *D. Bohm, L. Foldy*. 25 p.

In accelerators of the type discussed by Veksler and McMillan (e.g., the synchrotron and synchro-cyclotron) the motion of particles can be described in terms of stable oscillations about a synchronous orbit Expressions are worked out for the frequencies of these oscillations, and for the way in which their amplitudes are damped as the energy is increased. The effect of radiation losses on the damping is discussed. It is shown that the synchrotron can advantageously be operated as a betatron until the electron velocity is close to that of light; the dee voltage is then turned on and the machine works as a synchrotron for the remainder of the acceleration. The transition from betatron to synchrotron operation proved to be quite efficient. Formulae are given for the distortions of the orbits by azimuthal asymmetries of the magnetic field. The results are illustrated in terms of the California synchrotron.

MDDC 14 Fissionability Studies, by *L. B. Borst, J. J. Floyd.* 3 p

A special photographic emulsion of low general sensitivity has been developed. Fission fragments record as tracks in this emulsion whereas alpha particles and protons do not record as tracks, but only produce general fog. The selective sensitivity of these plates to fission fragments has been used as a basis for determining the thermal fissionability of several nuclear species. The photographic plate in contact with a deposit of the substance under investigation was exposed to a strong thermal neutron source. The developed plate was examined with a microscope for fission tracks. Reasonable estimates have been made of the size of the sample and the areas examined. The following values constitute probable upper limits to the thermal fission cross-sections of the substances indicated.

$Pb^{204} < 1.7 \times 10^{-28}$ cm^2
$Pb^{206} < 1.1 \times 10^{-29}$ cm^2
$Pb^{207} < 1.1 \times 10^{-29}$ cm^2
$Pb^{208} < 5 \times 10^{-30}$ cm^2
$Bi^{209} < 2.5 \times 10^{-30}$ cm^2
$Po^{210} < 10^{-25}$ cm^2

MDDC 15 Diffraction of Neutrons and Neutron Absorption Spectra, by *L. B. Borst, A. J. Ulrich, C. L. Osborne, B. H. Hasbrouck.* 2 p.

A crystal spectrometer has been constructed for the diffraction of neutrons. A collimated beam of neutrons from a chain reacting graphite-uranium pile impinged upon a large crystal. The diffracted beam passed through a second collimator and boron counter. Crystals used have been calcite, lithium fluoride, and quartz. Greater intensities were obtained by using the reflected beam from a quartz crystal of variable curvature. Angular resolutions of less than four minutes have frequently been used.

The crystal spectrometer has been used as a velocity selector to study the neutron absorption spectra of several elements of large thermal cross-section. The low-lying resonance levels may be accurately fitted to a Breit-Wigner formula of the following form:

$$\sigma \sqrt{E} = \frac{\sigma_o \sqrt{E_o}}{1 + \left(\frac{E - E_o}{\Gamma}\right)^2}$$

where σ = Total cross section at neutron energy E (cm^2)
σ_o = Total cross section at resonance,
E_o = Resonance energy (ev)
Γ = Resonance width (half-width at half maximum) (ev)

MDDC 16 Energies of the Delayed Neutrons from U^{235} Fission Products, by *M. Burgy, L. A. Pardue, H. B. Willard, E. O. Wollan.* 22 p.

A study of delayed neutron energies from U^{235} fission products has been made by measuring recoil proton tracks in a hydrogen-filled cloud chamber. A sample of uranium was irradiated in a graphite pile by means of pneumatic tube, and brought to the cloud chamber for observation. Five different times of irradiation and decay were used so as to give different proportions of the five delayed neutron activities studied. From composite neutron energy distribution curves, the curves for the separate activities have been obtained. The average energies lie in the region from 0.2 to 0.8 Mev. There is no simple relation between energy and half-life.

MDDC 17 Radiation Chemistry, by *M. Burton.* 21 p.

In the field of atomic energy there is a branch of chemical kinetics, corresponding to photochemistry, which in the atomic energy projects has been called radiation chemistry. In the atomic energy pile and in the subsequent processes for separation of plutonium and fission products from parent uranium, quantities and intensities of radiation far exceed those from any previously known natural source. The term "radiation," as here used, includes also high-energy particles; the radiations whose chemical effects had to be determined in advance of operations included beta, gamma, fast neutrons, and fission recoils as well as others. Sources of radiation used in the work included cyclotrons, Van de Graaf generators, betatrons, x-ray machines, and piles. A new *discomposition* effect in solids was discovered. Typical results on solids, water, and organic compounds are reported. The first important step (other than simple excitation) in radiation chemistry processes is ionic discharge. The ensuing chemical processes depend on the nature of the medium. Three principles seem to govern: the Franck-Condon principle, the principle of increased probability of internal conversion with increase in molecular complexity (Franck), and the principle that the ionic configuration is more nearly like that of the uncharged molecule the greater the size of that molecule. Illustrative examples are cited.

MDDC 18 **Pile-Produced Radioisotopes of Half-Life 12 Hours**, by *W. E. Cohn*. 5 p.

Listed in four attached tables are those radioisotopes, fission and otherwise, which have half-lives of 12 hours or longer and which can be produced in practical quantities in the Clinton pile. Included in the tables are significant physical and chemical data and remarks indicating the capacity of the present personnel and facilities to produce the materials. It is intended to publish these tables as part of the initial announcement of national radioisotope distribution (off-project), as a sort of catalogue, along with information relating to the method of obtaining them, cost data, etc. The half-lives and energies quoted are those available April 18, 1946.

MDDC 19 **Radiochemistry and the Fission Products**, by *C. D. Coryell*. 22 p.

Radiochemistry is defined as the chemistry of the isolation and identification of radioactive atoms, including the techniques of tracer analysis, together with the chemical problems associated with the genesis of radioactive substances. A historical report of the discovery of nuclear fission and the Metallurgical Project is mentioned.

The development of piles and the large-scale separation of plutonium from the products of fission chain reaction required a large-scale program of radiochemistry, with particular reference to the fission products. It was known in 1941 that fission was a rich source of radioactive isotopes, some 70 being known, including representatives for all elements from Se through Ce, in chains of beta emitters with up to four active members. It is obvious that one of the tasks was the determination of all the characteristics--yield, half-life, chain relations, mass assignments, and decay energies--that could be established with reasonable precision. Special techniques had to be developed for the study of rare fission products and for operations on very active samples.

Data are presented indicating the chemical implications of the fission process, and the implications to inorganic and physical chemistry of important fission isotopes.

MDDC 20 **A Graphical Method for Determing Particle Trajectories**, by *W. E. Parkins, E. C. Crittenden, Jr.*. 7 p.

A graphical ray tracing scheme is described which gives improved accuracy for tracing particle orbits of the type encountered in the cyclotron, betatron and synchrotron. The method allows a large increase in scale factor by eliminating the need for a compass arm. The motion of the particle is deduced from the motion of a working point, related to the instantaneous centre of curvature of the particle orbit.

MDDC 21 Methods for Betatron or Synchrotron Beam Removal, by *E. C. Crittenden, Jr., W. E. Parkins.* 12 p.

To date devices of the betatron and synchrotron type for accelerating electrons to high energies have not been adapted to bringing the electrons out in a beam for study, but rather have made use of the X-rays produced by the electrons striking some internal target. In the following, two methods are described which may be used to eject a partially collimated electron beam from such devices.

After release the electrons move outward with increasing radial velocity. If allowed to continue, they leave the magne ic field of the accelerator producing a sheet of energetic electrons spread uniformly through 360° of azimuth. In a large accelerator this radial velocity is a convenient one for handling the released electrons in a focussing field. If the magnetic field is altered over a small range of azimuth the electrons can be made to emerge as a partially collimated beam The electrons could be similarly handled in an electric field but proper shaping of an electric field seems to have practical difficulties.

The second method to be discussed for producing a collimated beam of electrons is in effect an extreme case of concentrating the range of azimuth in which electrons pass into the region of instability. For large accelerators it seems probable this method could produce a fairly well collimated beam without the help of an auxiliary focussing field. By allowing the orbits to expand almost to their edge of instability, deflection of the entire beam could be accomplished with a reasonable electric or magnetic field, provided this field could be applied in the form of a flat-topped pulse, rising in a time short compared to the period of revolution of the electrons.

MDDC 22 Proposed Neutron Spectrometer in the 10 1'000 Kev Range, by *B. T. Feld.* 2 p.

An exoregic (n,p) reaction might be used as a neutron spectrometer in the following way: a proportional counter is filled with a gas containing a substantial amount of the nucleus undergoing the (n,p) reaction. (Argon could be added to provide for sufficient stopping power to prevent more than a small fraction of the emitted protons from hitting the walls of the chamber.) If the energy of the reaction is E_r, and the energy of the neutron causing the reaction E_n, the total energy going into ionization would be $E_r + E_n$, and the pulse height would be proportional to $E_r + E_n$. A measurement of the pulse height would then yield the energy of the neutron causing the reaction. If a distribution of the neutron energies impinged on the chamber, analysis of the pulse height distribution, together with a knowledge of the variation of the (n,p) cross section with neutron energy, would give the energy distribution of the impinging neutrons.

The reactions which seem most promising for this application are N^{14} (n,p) C^{14} and Cl^{35} (n,p) S^{35}. Both of these reactions are exoergic with E_r 500 Kev.

The N^{14} (n,p) C^{14} cross section has been carefully investigated in the range under discussion by H. Barshall at Los Alamos. He found a number of sharp (n,p) resonances between 100 Kev and 1 Mev which limit the usefulness of this reaction to monoenergetic neutrons or to neutrons distributions below the lowest resonance (~ 400 Kev).

The author knows of no investigations of the Cl^{35} (n,p) S^{35} cross section in the fast neutron region.

It should be pointed out that the use of exoergic (n,p) reactions in a neutron spectrometer has the advantage over the use of proton recoils that it can detect lower neutron energies and that it does not require any collimation, either of the impinging neutron beam or of the resulting protons.

MDDC 23 The Multi-Channel Pulse Analyzer, by *A. Ghiorse.* 10 p.

The pulse analyzer consists of an ionization chamber and electronic units which make it possible to record the energy distribution of alpha disintegrations in a radioactive sample. In particular it is used to measure the amounts and determine the nature of alpha disintegrations in a mixture of isotopes. In practice it is necessary to use a large ion chamber with purified argon and thin samples.

The sequence of events in recording a pulse is as follows: The pulse developed on the collecting electrode of the ion chamber is amplified first in the pre-amplifier, then in the main amplifier. The signal which is now of the order of a hundred volts is 'clipped' off in the pre-discriminator, and the remainder further amplified. It is then applied to 48 thyratron selector units which respond to successively differing pulse heights. If two succeeding units are activated by the pulse, the resulting signals cancel and the register does not record.

The register, however, which corresponds to the unit which is activated when the succeeding one is not, does record, and thus each pulse is recorded on one of the registers, and the number of the register indicates the magnitude of the original pulse. Circuits included.

MDDC 24 A Method for Measuring Half Lives, by *R. Walker, A. Graves.* 6 p.

Measurement of the half life of an artificial activity with a counter has usually required a correction for counting losses. This correction is time-consuming and is not easy to make with precision. A method for measuring the half lives with Geiger counters which is independent of counting losses is described. Foils which have been irradiated for various times are counted after a lapse of time adjusted to make the counting rates the same. Saturated activities of the foil will be different if an incorrect value of the decay constant has been assumed. Equations are given for obtaining a more nearly correct value of the decay constant. The method is illustrated by data on the 54-minute period of indium.

MDDC 25 **Assignment of Mass to 46 Hr. Samarium and 9.2 Hr. Europium by a Mass Spectrograph**, by *R. J. Hayden, M. G. Inghram.* 1 p. (abstract only)

A nitric acid solution of Sm_2O_3 was irradiated by slow neutrons to produce the 46 hr. samarium activity reported in Seaborg's table. Part of this irradiated sample was placed on the filament source of a mass spectrograph. By operation of the spectrograph the samarium isotopes were separated according to mass on a photographic plate. After removal from the spectrograph, this plate was placed face to face with another photographic plate. With the passage of time the particles emitted from the active isotopes on the first plate gave rise to a developable image on the second plate. After both plates were developed, the original plate showed the normal spectrum of samarium (Sm^+ and SmO^-) while the second plate showed only two lines. These corresponded to masses 153 and 169 on the original plate. Due to the emission of the form SmO^+ the activity at mass 169 was ascribed to the same isotope as was the activity at mass 153. A decay curve of a second portion of the irradiated samarium solution showed that more than 95% of the activity was due to the isotope with 46 hour half-life. Thus it is concluded that the mass of 46 hr. samarium is 153.

A nitric acid solution of Eu_2O_3 was irradiated by slow neutrons to produce the 9.2 hr. europium activity reported in Seaborg's table. The same mass spectrograph technique was applied to this sample as to the samarium sample. In this case the second photographic plate showed a single line corresponding to mass 152 on the original plate. A decay curve of a portion of the irradiated europium solution showed that more than 95% of the activity was due to an isotope with 9.2 hr. half-life. Thus it is concluded that the mass of 9.2 hr. europium is 152.

MDDC 26 Higinbotham Scale of 64, Mark 5 Model 3, by *W. Higinbotham.* 2 p.

This scaling instrument is built for use with a self-quenching Geiger-Mueller tube.

An electronically regulated positive high voltage supply, variable from 600 to 1500 volts, furnishes the voltage to the center electrode of the Geiger-Mueller tube through a filter network and a one megohm load resistor. A 50 micromicrofarad coupling condenser connected directly to the center wire of the Geiger-Mueller tube delivers the pulse obtained from the G-M tube to the grid of the first amplifier tube. The input accepts negative pulses and is usually adjusted to just accept a pulse of .25 volts in height and 1 to 1 1/2 microseconds in width.

The scale of 64 is of the Eccles-Jordan type as modified by Higinbotham. The scaler will operate on evenly spaced pulses to a speed of at least 150,000 counts per second. In operation the scaling speed is limited by the recorder used with it. The output stage of the scaler was designed to be used with a Wizard Recorder. Thus the top operating speed is approximately 30,000 counts per minute. In normal operation the resolution loss is negligible.

The recorder used is the Wizard type E C 84 made by Production Instrument Company. Circuit included.

MDDC 27 Radiative Capture Cross-Sections for Fast Neutrons, by *D. J. Hughes.* 6 p.

For neutron energies higher than some hundreds of kilovolts resonance phenomena are not expected to occur because the spacing of nuclear levels is less than their width. As a result the (n,γ) cross-sections for fast neutrons might vary regularly with atomic weight. The radiative capture cross-sections for fast neutrons of about thirty isotopes of stable elements have been measured by using fast neutrons from the chain-reacting pile of the Argonne Laboratory as the neutron source and measuring the resulting beta activity. The main results are: (1) The cross-sections do not vary at random from isotope to isotope as do the thermal values but follow a smooth curve within experimental error. (2) The cross-sections for atomic weight (A) less than 100 decrease very rapidly with decreasing A from about 10^{-1} barn (1 barn = 10^{-24} cm^2) at A = 100 to about 10^{-4} b at A = 15. (3) The cross-section seem to remain roughly constant above A = 100 except for Pb and Bi which fall abnormally low. (4) There is evidence that in the case of isomers the isomeric branching ratio is the same at high energy as at thermal.

MDDC 28 **An Apparatus for Measuring Joule-Thomson Effects in Gases by Direct Expansion Through a Valve**, by *H. L. Johnston*. 18 p.

An apparatus is described for measuring Joule-Thomson effects in gases by expansion through a valve designed to minimize errors from thermal conduction. Satisfactory results were obtained with valves having valve stems of ebony and valve seats of either lucite or lignum vitae. Provision is also made to eliminate the "jet kinetic energy effect" in measuring the temperature of the expanded gas.

Results obtained with hydrogen show that the measured effect is independent of flow rate, between 3 and 60 CFM which indicates that thermal conduction and "jet kinetic energy effect" are absent. They also show a rapid response to variations in pressure, of the correct magnitude and sign, but show some lag in attaining thermal equilibrium when the inlet temperature of the gas changes rapidly. Equilibrium is attained within five to ten minutes at high flow rates and within 15 minutes to half an hour at low flow rates, under conditions of good pressure and temperature control.

A vacuum-tight cryostat vessel convenient in low temperature work for which visibility of bath level or apparatus is wanted is also described.

MDC 29 Joule-Thomson Effects in Hydrogen at Liquid Air and at Room Temperature, by *H. L. Johnston, I. I. Bezman.* 23 p.

Joule-Thomson effects in hydrogen have been measured for pressures up to 3000 pounds and for isotherms at 64° 69°, 75°, 80°, and 288°K. Measurements were made with the apparatus described in MDC-28. The method consists, essentially, in measuring the temperature drop when high pressure hydrogen is expanded through a needle valve made from thermally non-conducting materials.

The four low temperature isotherms exhibit flat maxima at 2200-2300 lbs. pressure. The magnitudes of the Joule-Thomson cooling effects at the several maxima are as follows: 23.4° for the 64° isotherm; 21.9° for the 69° isotherm; 19.7° for the 75° isotherm; 18.4°for the 80° isotherm.

The 15°C isotherm rises with a slight upward inflection with an average Joule-Thomson coefficient of approximately two degrees warming per 1000 pounds of pressure drop.

Comparisons are made with Joule-Thomson effects computed from hydrogen data of state and other appropriate data.

A table of heat contents, as a function of pressure and of temperature, is computed from the smooth isotherms of the data presented.

Curves are also given for the thermodynamic efficiency of hydrogen liquefaction as functions of temperature and pressure, computed from the measurements of the Joule-Thomson effect. These curves agree well with experimental results with an efficient hydrogen liquefier.

MDDC 30 Joule-Thomson Effects in Deuterium at Room Temperatures, by *H. L. Johnston*. 16 p.

Joule-Thomson effects in deuterium have been measured for pressures up to 2800 pounds per square inch and for isotherms at 64°, 69°, 75°, 80°, and 298°K. Measurements were made with the apparatus described by Johnston and used previously to measure Joule-Thomson effects in hydrogen, with some improvements in operating conditions-notably in temperature control.

Each of the low temperature isotherms exhibits a flat maximum at 2400-2500 lbs. pressure. The magnitudes of the Joule-Thomson cooling effects at the several maxima are as follows: 25.7° for the 64° isotherm; 21.8° for the 69° isotherm; 19.9° for the 75° isotherm and 16.9° for the 80° isotherm. The maxima are somewhat flatter than those observed for hydrogen. The 64° curve lies above that for hydrogen in the high pressure region, but the relative positions of the curves is reversed for the 75° and 80° isotherms.

The 25° isotherm rises with a slight upward inflection with an average Joule-Thomson coefficient of approximately 2.1 degrees warming per 1000 pounds of pressure drop.

A table of heat contents, as a function of pressure and of temperature, is computed from the smooth isotherms of the collected data.

The accuracy of the measurements made with deuterium exceeds that obtained with hydrogen. This is due principally to better temperature control obtained through the use of liquid nitrogen as cryostat bath liquid.

MDDC 31 Counter for Use in Scattering and Disintegration Experiments, by *P.G. Koontz, T. A. Hall*. 13 p.

A description is given of a chamber used for studying the angular distribution of scattering of neutrons by helium. This counter can be used either as an ionization chamber or as a proportional counter. Results of tests made with the N (n,p) reaction for slow neutrons are included. These tests show a width of the 0.6 Mev line at half height to be about 35 Kev., indicating that it should be possible to separate low-energy neutron groups which differ in energy by about 50 Kev.

MDDC 32 Scattering of Fast Neutrons by Helium, by *P. G. Koontz, T. A. Hall.* 45 p.

Measurements have been made of the angular distribution of helium recoils for incident neutrons of energies from 0.6 to 1.6 Mev. The distribution curves also permit estimates of the total cross-section in this energy range. The results confirm the existence of a cross-section peak around 1 Mev and indicate, under the assumption of s-and p-wave scattering only that the peak is double. But attempts to fit the date to Bloch's detailed theory of 2- and p-scattering with a split p-level have not been successful, and the sign of the postulated splitting is not established.

MDDC 33 Nucleonics and the Chemical Engineering Curriculum, by *N C. Leverett.* 8 p.

The fundamental sciences for a chemical engineer are clearly mathematics, physics, and chemistry, Of these, mathematics and physics deserve much more emphasis than they seem currently to receive. A first class chemical engineering graduate should be able to handle ordinary differential equations well, and should have considerable familiarity with series problems and the more common problems of partial differential equations. He should have a good grounding in general physics, including optics, mechanics, electricity, magnetism, and sound, and should have had a good foundation in modern physics as well. The chemical training received by most chemical engineers has proved adequate for work in nucleonics so far, due possibly in part to the fact that most of the chemistry involved is inorganic chemistry, which has so far become less specialized than organic chemistry. With the increasing emphasis on mathematics and physics, one may question whether the student should be called a chemical engineer or by some other name such as physico-chemical engineer, since he will have a broader understanding of physical problems than does the present chemical engineer.

MDDC 34 Chemical Isolation of the 56-Second Bromine and the 23-Second Iodine Delayed Neutron Activities, by *A. H. Snell.* 14 p.

The 23-second delayed neutron activity is found to follow the chemistry of iodine and the 56-second delayed neutron activity is found to follow the chemistry of bromine. The nuclei which emit the delayed neutrons are probably Xe^{137} and Kr^{87}, although possible coincidences in half-lives are not ruled out whereby the mass numbers may be larger.

MDDC 35 Pile Kinetics, by *L. W. Nordheim.* 5 p.

A pile will run steadily at an arbitrary level if it is just critical. For a pile not at equilibrium, equations of motion can be set up that contain as variables the pile power, the number of delayed neutron emitters, and in case it is of importance, also the pile temperature. The coefficients will depend on the average lifetime of the neutrons in the pile, the fractions and periods of delayed neutrons, temperature coefficients of reactivity and similar quantities. For a definite 'excess reactivity' which may be positive or negative, the power level will change exponentially with time with periods determined by the so-called 'inhour' relation. For control and safety problems the transient behavior of the pile under reactivity changes has to be investigated. A number of limiting cases can be solved explicitly A general method for the solution of the pile equations is available for small deviations from a steady state. In this case a pile impedance can be defined in close analogy to electric circuit theory

MDDC 36 Manufacture of Carbon 14 in the Chain-Reacting File, by *L. D. Norris, A. H. Snell, E. P. Meiners Jr , L. Slotin.* 9 p.

Using the reaction N^{14} $(n,p)C^{14}$, carbon 14 can be manufactured in a chain-reacting pile in three ways; batch processing of irradiated, solid, nitrogenous material, continuous extraction from some kind of emanating nitrogenous substance, and continuous extraction from a liquid such as ammonium nitrate solution. A 'factory' of the latter type has been in use at Clinton Laboratories. The solution is circulated through the pile with a glass centrifugal pump and the active carbon is carried out, mostly as CO_2, with the other gases resulting from radiation decomposition of the liquid. The carbon 14 dioxide is precipitated from the gas stream as barium carbonate. The isotopic concentration is about 5% C^{14}; two early samples analyzed 3.3% C^{14} with the mass spectrometer.

MDDC 37 The total Scattering Cross Sections of Deuterium and Oxygen for Fast Neutrons, by *R. E. Nuchols et al.* 11 p.

The transmissions of H_2O and D_2O for neutrons of discrete energies between 0.35 and 6.0 Mev have been measured These neutrons were produced by Li (p,n) C (d,n), and D (d,n) reactions with monoenergetic ions accelerated by the Minnesota pressure electrostatic generator Previous experimental values of the (n,p) scattering cross section in the same energy region by the same technique were used to calculate $\sigma_s(D)$ and $\sigma_s(O)$ from the observed transmissions of H_2O and D_2O $\sigma_s(D)$ is a monotonic function of neutron energy in this region. $\sigma_s(O)$ shows evidence of resonance phenomena.

MDDC 38 **Design of Dynamic Condenser Electrometers**, by *H. Palevsky, R. K. Swank, R. Grenchik.* 65 p.

At present, all electrometers may be arbitrarily divided into three classes: (1) Mechanical Electrometers, (2) Vacuum Tube Electrometers, (3) Dynamic Condenser Electrometers.

Mechanical electrometers are instruments in which the charge to be measured exerts a force on a mechanical system. Vacuum tube electrometers are instruments in which the charge develops a potential difference across the two elements of a vacuum tube. In dynamic condenser electrometers, mechanical energy is used to move the impressed charge in an electrostatic field. It is essentially a condenser whose capacity is varied periodically. If the methods of placing a charge on the dynamic condenser are considered, nearly all methods will involve some capacitance placed across the input terminals. Because of grid currents and variations in grid currents, it is essential that the input resistor of the amplifier be made as low as possible. In general, the conditions for maximum sensitivity are low dynamic condenser capacitance and low grid circuit noise.

Zero drift and high impedance drift limit the long term sensitivity of dynamic condenser electrometers. A negative feed back has no effect on the noise referred to the input and consequently does not change the signal to input circuit noise ratio. No attempt is made to specify the design of the most ideal dynamic condenser. Various factors are concerned such as: mechanical factors, zero-drift, background currents, and shielding. Both rotating and vibrating condensers have respective advantages. The vibrating reed electrometer is used to measure very small currents, either by measuring the rate of change of its capacitance, or by measuring the potential difference developed across a high resistance. The vibrating diaphragm electrometer was designed to replace the vibrating reed electrometer in applications where compactness or portability is essential.

MDDC 39 The Neutron Spectra of Po-B and Po-Be, by *I. H. Perlman, H. T. Richards, Lyda Speck.* 15 p.

Recoil protons in photographic emulsions have been used to record the neutron spectra of Po-B and Po-Be. The photographic emulsions have been calibrated with monochromatic neutrons from the $Li^7(p,n)Be^7$ reaction and the d-d reaction. The use of thick (200 micron) emulsions unbacked by glass is described. The inferred neutron spectrum for Po-B shows a broad maximum at ~ 2.5 Mev and extrapolates to zero at about 6 Mev on the high energy side. No group structure is found. The inferred neutron spectrum for Po-Be shows a maximum between 2 and 3 Mev but has an average energy of more than 4.6 Mev. The high energy end extends beyond 10 Mev. Some group structure may be present, but the large intensities of neutrons with energy less than 2 Mev which earlier workers report is not corroborated.

MDDC 40 Health Physics Building Surveying at Clinton Laboratories, by *W.H.Ray* 12 p.

Building radiation surveying was developed at Clinton Laboratories to provide the qualified Health Physics information needed by perators and research personnel It was discovered that a definite well-integrated program was necessary if personnel exposure to incidental radiation was to be held to a safe minimum Careless handling of materials and equipment, contamination of ordinary articles of wearing apparel and of such things as phones and reports had to be continually guarded against. Overall surveying of such operations as loading slugs from the pile for shipment and repairing equipment involved in direct operations was also carried out under the surveillance and with methods approved by the Health Physics Section. A Job Instruction Training breakdown was used to advantage. Authority to requisition Safety equipment and materials was invested in departmental supervision.

MDDC 41 Frequency Modulated Cyclotron, by *K. R. MacKenzie et al.* 6 p.

The application of the synchrotron phase stability principle to the frequency modulated cyclotron has been investigated experimentally on the 37 inch Berkeley cyclotron. The relativistic increase of mass was simulated by a radial decrease in magnetic field.

The purpose of the experiments described was to simulate the acceleration of deuterons to 200 Mev in the giant, 184-inch cyclotron.

By modulation of the accelerating r.f. potential through 20% at 600 c/s (by a mechanical rotating capacitor) deuterons were accelerated to 7 Mev the maximum without frequency modulation being 0.5 Mev. The corresponding maximum for the 184-inch cyclotron would be 200 Mev deuterons.

In view of the success of these experiments it has been decided to complete the 184 inch instrument as an FM cyclotron

Appreciable values for the time average current of 200 Mev deuterons would be expected from the giant cyclotron even with 3 kv on the dee. At ordinary dee voltages of 50 kv, say, the output would be larger both due to the increase in efficiency and the increase in source efficiency. A reasonably conservative expectation would appear to be a time average current of one microampere of 200 Mev deuterons with 50 kv on the dee FM system will also have advantages for smaller cyclotrons where it is desired to obtain high energy protons with reasonable dee voltages.

MDDC 42 Theory of Pile Control Rods, by *R Scalettar, L. W. Nordheim.* 10 p.

A control rod absorbs neutrons and increases the leakage of neutrons from the pile through the depression of the neutron density in its vicinity To determine the effect of controls on critical conditions for a pile the absorber may be considered as in the electrical analogue, to produce a singularity in neutron density at its position. The strength of such a singularity is determined by the boundary conditions which must be satisfied at the surface of the black or non-black absorber and the order of the singularity is determined by the geometry of the problem. The general solution of the pile equations can then be expressed by a sum of a regular solution plus the solution containing the proper singularities, and this total solution can be adjusted to satisfy the boundary conditions. By this means the effect of control rods of various sizes and positions on pile reactivity and neutron distribution and the effects of mutual control rod shading have been investigated both by a thermal and by a two-group theory

MDDC 43 **Energy-Angle Distribution of Betatron Target Radiation, by *L. I. Schiff.* 3 p.**

An approximate expression by Sommerfeld for the energy-angle distribution of the bremstrahlung produced by fast electrons in a thin target was found to be not applicable when the target is of the thickness used in betatrons. A formula is deduced for a thick target by integrating Williams' formula (Physical Review *58*, 292 (1940) and curves are given for 3 thicknesses of a W target. Variations of incident electron energy only affect the scale of the curves.

MDDC 44 **Mechanical Frequency Modulation System as Applied to the Cyclotron, by *F. H. Schmidt.* 20 p.**

A high-speed, variable capacitor operating in a vacuum is described. The capacitor is coupled to the cyclotron dee by means of a transmission line whose length is such that a voltage node occurs near its center. The frequency change obtained is greater than 13 per cent. The frequency-time characteristic of the system is considered and a method of adjusting the shape of the characteristic is described.

MDDC 45 Design, Construction, and Freliminary Tests of a Double-Focussing Mass Spectrograph, by *A. E. Shaw, W. Rall.* 16 p.

The purpose of this investigation was to design and construct a mass spectrograph for the analysis of solids over a large mass range and capable of rapid and easy operation. Commercial models for gas analysis have been available for some time, but until now no commercially engineered mass spectrograph has been available for the analysis of solids. Existing laboratory instruments capable of handling solids do not, for the most part, possess features that permit rapid efficient, and easy operation.

Since it was deemed desirable to attain good resolution over a large mass range in a single exposure, the instrument was designed in accordance with the theory of Mattauch.

In 1936 Mattauch presented the theory of a double-focussing mass spectrograph. This is a special case of the general theory of all combinations of a radial electrostatic field and a homogeneous magnetic field published two years earlier by Mattauch and Herzog. This special case satisfies the conditions for double-focussing, that is direction and velocity focussing, over the entire range of the photographic plate

The preliminary results thus far obtained reveal the suitability of this instrument for routine qualitative analysis. Since each exposure covers such a large mass range, two or at most three exposures should embrace all elements. Thus on one plate it should be possible to ascertain the presence of any element

MDDC 46 Manual for the Proportional Alpha Counter (Model 1-C). by *J. A. Simpson, Jr.* 29 p.

The purpose of the manual is to provide information and data on the Model 1-C which is of use to technicians and the instrument men who must keep such units in service. The description includes the new, low-geometry, vacuum chamber which is interchangeable with the mechanism for inserting samples. The theory of operation of the counter and the experimental details of the counter are described in MDDC-80. However, the latest (March 20, 1945) circuit changes and mechanical changes appear in this manual.

MDDC 47 **The Chemical Significance of Modern Nuclear Science and Technology, a Symposium by Oak Ridge Scientists, IV. The Fractionation of Isotopes, by *A. H. Squires*. 14 p.**

It is shown that fractionation is a process which multiplies a sepration effect by setting up a sequence of separation steps between which partially separated fractions are recycled. In principle any separation effect may be exploited in a fractionation device. Separation effects available for isotopic fractionation are classed as: centrifugation, thermal diffusion, chemical change, and gaseous diffusion. Operational theory and practical application of each is discussed. The gaseous diffusion process is discussed more fully, and applicatfons and references concern the K-25 plant at Oak Ridge.

MDDC 48 **Radiation from Fission Products, by *I. Way, E. P. Wigner.* 3 p.**

A fissioning nucleus can divide into any of about twenty pairs of product nuclei. Each product nucleus is in general unstable and goes through several radioactive β-transitions before it reaches stability. Each transition, of course, has its own peculiar radiations and lifetime. The radioactivity which follows a number of fissions is thus made up of a number of individual activities of many periods and energies. The energy emitted per second per fission at time t after fission is given by

$$\int_0^{\lambda MAX} \lambda\, N(\lambda,t)\, E(\lambda)\, d\lambda$$

where $N(\lambda,t)$ is the number of nuclei of decay constant λ existing at the time t after a fission. Evaluation of this expression gives, for times greater than one day, the result

$$\text{Mev/sec/Fission} \approx 3.75t^{-1.2} + 96t^{-14}$$

where t is measured in seconds. For shorter times a curve is given. This is the total energy emitted including that carried by neutrons. Agreement with experimental results is fairly good. Handy rules of thumb giving correct values within a factor of two for times between 10 sec and 100 days are:

$$B + \gamma \text{ Mev/sec/fission} = 2.66\ t^{-1.2}$$

$$\gamma \text{ Mev/sec/fission} = 1.26\ t^{-1.2}$$

The total disintegration energy per fission turns out to be

$$\approx 22 \pm 3 \text{ Mev.}$$

MDDC 49 New Opportunities and New Responsibilities for Scientists, *M.D. Whitaker.* 7 p.

A discussion is presented of the new opportunities and the new responsibilities which have arisen as a result of the tremendous scientific effort spawned by the late war. Against a chronological and historical background, the phenomenon of atomic fission is traced to the present and generalizations are forecast as to future problems, techniques, and developments pertinent to scientific endeavor.

Opportunities for scientists and students in scientific fields are mentioned.

MDDC 50 Plans and Problems in Nuclear Research, by *Farrington Daniels.* 23 p.

A general review and delineation of the major problems which have been the outgrowth of the development of atomic energy is presented. The programs and problems discussed are under the following headings: piles, radioactive isotopes, chemical research, health, biology, new tools, atomic power, safety, secrecy, publication, shortage of scientists, research policies, and regional laboratories. In conclusion the problems of internation control and organization to prevent war are indicated, and scientists are given the responsibility and privilege of leadership in bringing about effective machinery for permanent peace.

MDDC-51 Total Cross-Section of Carbon and Hydrogen for Neutrons of Energies From 35 to 490 Kev, by *D. H. Frisch.* 11 p.

The total cross-section of hydrogen has been measured at mean neutron energies of 35, 95, 265, and 490 Kev. Protons from the smaller Wisconsin electrostatic generator at Los Alamos, collimated to a 3/32" diameter beam, bombarded a lithium target of 5 to 10 Kev stopping power. The nearly monoenergic neutrons emerging forward were scattered out of a proton recoil proportional counter by graphite and polythene discs. Sources intensity was monitered by a small sensitive fission counter between source and scatterer. A polythene shadow cone reduced the counting rate to about 2%. The errors given for the corrected data include estimates of error in scatterer thickness and in geometrio corrections (only to the statistical error given for the uncorrected data. The values obtained are respectively: Uncorrected 16.15 ± .25, corrected 16.74 ± .41; 13.04 ± .26, 13.46 ± .39; 8.87 ± .15, 9.12 ± .24; 6.19 ± .15, 6.33 ± .21. This data and higher energy data by Williams et al. and Bretscher et al. have been fitted by Bohm and Richman with a potential consisting of a deep, square well with a wide shallow, square tail.

MDDC-52 New Developments in Vacuum Engineering by *R. B. Jacobs, H. F. Zuhr.* 42 p.

The development of leak detection techniques for the Gaseous Diffusion Plant for the separation of U-235 was one of the major engineering problems connected with the project A greater degree of tightness was required than had been achieved, hitherto, in any commercial plant, and the construction schedule did not permit the use of the time consuming methods generally employed. It was recognized accordingly, that vastly improved techniques were necessary to greatly increase the sensitivity and speed of testing otherwise a prolonged period of testing would intervene between the completion of construction and the initiation of operations. After all known methods and several new ones were considered, the mass spectrometer was selected as the basic testing instrument. This paper describes the techniques for leak detection developed with the mass spectrometer, and indicates the general utilization of those techniques.

MDDC-53 Recording Mass Spectrometer for Process Analysis, by *A. O. Nier, T. A. Abbott, J. K. Pickard.* 15 p.

A recording mass spectrometer is described which has been used for making continuous analyses of the process gas stream in the uranium gaseous diffusion plant. The strategic distribution of instruments in the plant assures rapid detection of any inleaking contaminants.

MDDC-54 Production of Low Energy Neutrons by Filtering Through Graphite, by *H. L. Anderson, Enrico Fermi, L. Marshall.* 6 p.

Neutrons of energy much lower than thermal were produced by filtering a beam of thermal neutrons through a block of graphite 23 cm long. In such a block Bragg scattering removes the neutrons whose wave length is less than the largest Bragg wave length in graphite, 6.69 Angstroms. Measurement of the boron absorption of the filtered neutrons showed that they had an effective wave length of 7.15 Angstroms which corresponds to neutron temperatures around 18 Kelvin. The cross-section of graphite for the filtered neutrons is 0.70×10^{-24} cm^2. That a part of this is due to the incoherence due to thermal agitation of the atoms of the crystal was demonstrated by heating the crystal and observing the increase in this cross-section

The filtered neutrons were used to show interference effects in other substances such as Be, Bi, and S. The fourfold increase in the scattering cross-section of hydrogen due to chemical binding was observed in water.

MDDC-55 Phase of Neutron Scattering, by *E. Fermi, L. Marshall.* 6 p.

A neutron wave may be scattered with a change in phase of either 0° or 180°. By studying the intensities of the orders of Bragg reflection for neutrons, one can compare the phase of neutron scattering of the different nuclei which compose a crystal.

A beam of thermal neutrons from the Argonne heavy-water pile was monochromatized by Bragg reflection from the 100 face of CaF_2. From a second crystal in the monoenergetic beam Bragg reflections of various orders were obtained.

The form factors were calculated from the positions and scattering cross sections of the atoms in the unit cell, and were compared with the observed variation of intensities of orders in several crystals. From the fact that carbon totally reflects neutrons, as found by Fermi and Zinn, it follows that the phase change for carbon is 180°.

The present investigation shows that O, Ca, Fe, S, Pb, F, and tentatively C scatter with the same phase shift, and that the phase shift for Mn is opposite. Consequently, the phase shift for the group may be tentatively identified as 180°, and that for Mn tentatively identified as 0°.

MDDC-56 Reflection of Neutrons on Mirrors, by *E. Fermi, W. H. Zinn.* 3 p.

The fact that neutrons are scattered by atoms leads one to expect that various materials will have an index of refraction n for neutrons $n - 1$ is positive or negative and of the order of 10^{-6}. When $n < 1$ one might expect total reflection for angles of a few minutes. The phenomenon is analogous to the reflection of x-rays, since they have wave length and scattering cross-section comparable to those of thermal neutrons.

The total reflection of neutrons has actually been observed as follows. A very narrow beam of thermal neutrons from the heavy-water pile of the Argonne Laboratory was obtained by collimating it with two slits one millimeter wide and placed 5 meters apart.

This beam was allowed to fall on polished surfaces of various materials with a very small and adjustable angle of incidence. The search for the reflected beam was carried out with BF_3-filled proportional counters with an entrance slit 2 millimeters wide and placed at a distance of 4.7 meters from the second collimating slit. Reflection was observed very intensively for angles of incidence up to 10' and for mirrors of graphite, glass, aluminum, beryllium, copper, zinc, nickel, and iron.

MDDC-57 The Decay of Cb^{94} (6.6 min), by *M. Goldhaber, M. H. Sturm.* 3 p.

In the studies of the activation of Cb by thermal neutrons an activity of very low intensity decaying with a half-life time of 6.6 min was found. A direct determination of the capture cross section of Cb leads one to expect an activation cross section about 150 times larger than previously reported. In calculating the activation cross section it had been assumed that β-rays are emitted by the 6.6 min. Cb^{94}. It was now found that this isotope, produced by exposure of very pure Cb_2O_5 to slow neutrons from the Argonne heavy water pile, decays mainly by K-electron capture to Zr^{94} rather than by β-decay to Mo^{94}. Critical absorption measurements in Rb and Sr show the presence of Zr K α X-rays. Because of the low efficiency of the normally used Geiger counters for these X-rays the big discrepancy between the activation and capture cross section can be qualitatively understood.

MDDC-58 A Critical Survey of Neutron Cross-Sections, by *H. H. Goldsmith.* 28 p.

The central problems in neutron research are the understanding of nuclear structure and the study of the properties of nuclear particles, particularly the properties of the neutron.

The most fruitful attack on these problems is the determination of the probability of interaction between neutrons and nuclei, i. e., the measurement of neutron cross sections.

Ideally, this involves the study of all possible types of neutron interaction with all available nuclei at all neutron energies.

There exist about 280 stable nuclei (if radioactive nuclei are included, there are closer to 1000 nuclei available for study). The various types of interactions are neutron absorption (n,γ; n,p; n,α), neutron production (fission and n, 2n), and neutron scattering (elastic and inelastic). The available range of neutron energy is from $< 10^{-3}$ ev to 10^{7} ev.

The discussion in this paper omits the interactions leading to neutron production, and is limited to the interactions of neutrons with stable nuclei.

MDDC-59 Neutron Cross Sections of the Elements, by *H. H. Goldsmith, H. W. Ibser.* 81 p.

A series of graphs are reproduced on which are plotted neutron energy vs. cross section values for many of the elements. A bibliography of Project Report references is included.

MDDC-60 Mass Spectrometric Observation of Radioactive C^{14}, by *N. G. Inghram.* 10 p.

A sample containing radioactive C^{14} prepared by the reaction $N^{14}(n,p)C^{14}$ was studied with a Nier-type mass spectrometer. The sample was obtained from Dr. Snell of the Clinton Laboratories in the form of $BaCO_3$ Analysis was accomplished using the CO_2 evolved, by heating the $BaCO_3$ in quartz to 1100°. The usual technique of liberating the CO_2 by addition of acid was not used for the following reasons: (1) Measurement showed that the first one-hundredth of the sample evolved by heating was not characteristic of the carbon isotopes in the sample. (2) In handling small quantities of CO_2 the solubility of CO_2 in the acid is important. (3) The heating technique removes the problem of trapping out unwanted vapors.

Curves obtained in the mass 42 through 48 positions showed a peak in the mass 46 position 9.3 times larger than that obtained for normal CO_2 This peak must be due either to O^{18} or C^{14} Measurement of the O^{18} concentration showed this to be normal.

Thus the mass of radioactive carbon is 14 in agreement with radioactivity predictions. Computation of the carbon abundances gave 95.61%. 1.04%, and 3.35% for the C^{12} C^{13} and C^{14} respectively. Correlation of this data with the specific beta activity of the sample gives a value for the half-life of C^{14}.

MDDC-61 The Neutron Absorbing Isotopes in Samarium and Gadolinium, by *R. E. Lapp, J. R. VanHorn, A. J. Dempster.* 3 p.

The large absorption for slow neutrons in samarium was found to be due to the isotope at mass 149, and in gadolinium to the isotopes at masses 155 and 157, the cross section for 157 being about three times that for 155. Mass spectra were made with the double focusing mass spectrograph using the spark with nickel tubes packed with oxide as electrodes. Mass spectra of normal samples were compared photometrically with those of samples in which this isotope abundances had been altered by long exposure to slow neutrons. In the altered gadolinium the abundance of mass 157 was less than 155 in place of greater, and 156 was greater than 160 in place of less. In samarium the abundance of mass 149 was reduced to be nearly as weak as 148, and mass 150 was correspondingly increased.

MDDC-62 The Preparation of Certain Halohydrocarbons, by *E. T. McBee.* 18 p.

When it became apparent that fluorocarbons, i. e., compounds containing only carbon and fluorine, would be useful in a process for the separation of the uranium isotopes U-235 and U-238 involving the use of uranium hexafluoride, methods for their preparation were sought. Methods leading to the preparation of bis (trifluoromethyl) benzenes and tris (trifluoromethyl) benzenes were investigated. A process for the preparation of a mixture containing perfluoroheptane and dichloroperfluoroheptane was developed.

Other formulas and compounds were developed as follows:

Chlorination of normal heptane, fluorination of polychloroheptanes with hydrogen fluoride, fluorination of polychloropolyfluoroheptanes with antimony, conversion of polychloropolyfluoroheptanes to perhaloheptanes, fluorination of perhaloheptanes with antimony pentafluoride, preparation of perfluorodimethylcyclohexane (C_8F_{16}) from technical xylenes, preparation of polyhaloethylbenzenes, and polyfluorodimethylcyclohexane. "Mirando-J" oil was converted to perhalo compounds by vapor phase fluorination with silver difluoride. Preparation of polyethylbiphenyls and polyethylnapthalene was reported.

Methods were developed for the decomposition and subsequent analysis of organic compounds containing fluorine and other halogens and for the determination of carbon in halocarbons containing fluorine.

MDDC-63 Recording Ionization Chamber for Traces of Radioactive Gases, by *A. O. Nier, C. M. Stevens, T. A. Abbott, J. K. Pickard.* 12 p.

A recording ionization chamber is described which has been used for the measurement of low concentrations of UF_6 in mixtures of nitrogen and oxygen. The chamber is constructed of non-corrosive material and designed to minimize the effect of radioactive contaminants which accumulate on the surfaces. Performance data are given. With UF_6 having normal isotopic concentration, one part in 10^6 can be measured; for UF_6 enriched in U^{235} the sensitivity is increased correspondingly.

MDDC-64 Mass Assignments of Some Radioactive Isotopes of Pd and Ir, by *W. Rall.* 6 p.

Mass assignments of the following activities produced in Pd and Ir by slow neutron absorption have been made by the mass spectrograph: Pd^{109} (13 hr) Ir^{192} (60 d), Ir^{194} (19 hr.). The Pd and Ir ions were produced by a high-frequency spark and were analyzed in a new double-focussing mass spectrograph. Mass lines of radioactive isotopes were identified by placing the emulsion of an unexposed plate in contact with that of the undeveloped collecting plate immediately after removal from the spectrograph. When developed after sufficient exposure to the beta particles, the transfer plate showed the active masses while the collecting plate showed inactive masses as well. Approximately 10^5 beta disintegrations are required to produce a line on the plates used compared to 10^7-10^8 Pd^+ ions of 12,000 volt energy. To obtain maximum intensity, all collimating slits were removed and the source slit was opened to 16 mm resulting in a resolution of about 100. The ratio of atoms consumed in the spark to singly charged ions collected was then found to be 5×10^7.

MDDC-65 Studies of Neutron Resonances with a Crystal Spectrometer, by *W. J. Sturm, S. Turkel.* 5 p.

Using the neutron crystal spectrometer described in MDDC-68, measurements have been made of total cross sections as a function of neutron energy for a number of elements. The method involving measurement of the transmission of a sample of the element in the reflected beam has been used in the region between .04 and 65. ev. At energies lower than .04 ev the high-order Bragg reflections contribute greater than 5% of the total observed effect, while the upper limit of the usable energy range is set by size of the glancing angle allowed by the present collimators. Strong resonances were observed in Cd at .182 ev; in Gd at ~ .03 ev; in Sm at .096 ev; in Eu at .465 ev; in Rh at 1.28 ev; in Ir at .635 ev, 1.35 ev, and 6.1 ev. The strong absorption of thermal neutrons in Dy was shown to have a negative energy level. It has been possible to analyze some of the resonance levels at low energy with the help of the Breit-Wigner one-level formula, and to assign values to the constants in this expression.

MDDC-66 Theory of Heat and Mass Transfer in Batch Condensation of Solids, by *W. I. Thompson.* 13 p.

A description of a refrigerated cold trap for condensing uranium hexafluoride as a solid from gas mixtures with nitrogen is reported. It was used as one of the auxiliaries of the Gaseous Diffusion Plant for separation of uranium isotopes Statement of the problem, general principles, derivation of design equations, discussion, and glossary of terms are presented.

MDDC-67 Crystal Structure Studies of Plutonium and Neptunium Compounds, by *W. H. Zachariasen*. 7 p.

The crystal structures of thirty two plutonium compounds and of thirteen neptunium compounds have been determined Most of these compounds were identified by means of the x-ray diffraction method, and crystal chemical considerations at a time when plutonium or neptunium were available in too small amounts to permit the use of microchemical methods of analysis. The crystal radii of plutonium and neptunium have been determined for the various normal valence states and for subnormal valence states observed in such compounds with metallic-type binding as PuO and NpO. The crystal structure results for normal-valence compounds have shown that electrons go into the 5f-shell, thus confirming the old hypothesis of a new rare earth series being started towards the end of periodic system. In the series of ions $(UO_2)^{+2}$, $(NpO_2)^{+2}$, $(PuO_2)^{+2}$ or Th^{+4}, U^{+4}, Np^{+4}, Pu^{+4}, or U^{+3}, Np^{+3}, Pu^{+3} there is a contraction in size with increasing atomic number analogous to the lanthanide contraction.

MDDC-68 The Bragg Reflection of Neutrons by a Single Crystal, by *W. H. Zinn*. 8 p.

The intense beam of neutrons which can be obtained from a chain-reacting pile has been used to study the diffraction of neutrons by a crystal. It is found that a neutron beam can be so collimated that the angular width is of the order of 10' and that a rocking curve obtained with a single crystal of calcite has the expected width. $CaCO_2$, LiF, and other crystals have been used to construct a single crystal monochromator for the study of resonance neutron absorption. The instrument, which is very similar to an X-ray spectrometer, is described. The spectrum of the neutrons from the reactor has been determined and the effect of 2nd and higher order reflections investigated.

MDDC-69 Magnetic Gear for Torque Transfer to an Enclosed System, by *T. A. Abbott, J. K. Pickard.* 10 p

Because of the corrosive nature of uranium hexafluoride and the extremely low permissible plant inleakage, no packing boxes or glands could be used. A special rotating seal through which the power shaft passes into the process is used on the centrifugal pumps. Bellows seals, some with and some without buffer zones, are employed in valves, instruments, and devices which require only limited travel.

A magnetic gear using permanent magnets has been developed for operating through a sealing diaphragm the vane of a butterfly valve in a vacuum-tight system. Data are given covering the design features of the magnetic circuit used in the gear.

MDDC-70 The Role of the Johns Hopkins University in the Development of the Atomic Bomb, by *W. B. Burford, III.* 8 p.

The Johns Hopkins University carried out a four-year program of research and development and manufacture of materials used in the manufacture of the atomic bomb.

The work of the Hopkins group was closely connected with the separation of uranium 235 from normal uranium, the principal contribution being the discovery, synthesis, and, later, the manufacture of special materials for the plant at Oak Ridge. In addition, the laboratory worked directly with the Army and other contractors on a variety of highly specialized problems which arose as the design, construction, and operation of the isotope-separation plants progressed.

MDDC-71 Chicago Tribune Articles, Photographs, and Correspondence, by *Chicago Tribune*. 6 p.

A newspaper story is presented based on a reporter's visit to the University of Chicago Metallurgical Laboratory. Techniques in ultra-microscopic measurement are indicated, together with general references to the security and secrecy status. A quartz fibre ultra-microbalance is discussed which will weigh substances to the order of one billionth part of a gram. A high temperature, high vacuum apparatus, which at 3500°F. can achieve a constant vacuum ranging to 1/100th of one billionth of an atmosphere, is mentioned. References to radiation counters and items of general interest are contained

MDDC-72 Theoretical Discussion of a Small Homogeneous Enriched Reactor, by *R. F. Christy*. 6 p.

A description of the "water boiler" is reported. The machine consists of the reactor proper surrounded by a neutron reflector which is surrounded by a shield except where it communicates with the graphite "thermal column". The reactor consists of a non-corrosive (stainless steel) shell about a foot in diameter containing the uranium enriched in 235 (or plutonium) as a water solution of a suitable salt such as UO_2SO_4 or $UO_2(NO_3)_2$

In a discussion of neutron design, calculations are carried out for the amount of U^{235} required, size of sphere required materials to be used as a neutron reflector size of reflector intensity of source, number of neutrons of various kinds and shielding needed

Output of the machine is discussed. The heat extraction is by means of a coiled tube carrying cold water through the inside of the reactor. The solution itself circulates simply by convection. A simple heat transfer calculation shows that a moderate-sized coil of about 20 feet of 1 cm tubing sufficies to remove about 10 kw. From this power one finds immediately that the flux (nv) of thermal neutrons in the reactor is about 10^{11}. In other words there are about 10^{14} fiss/sec in the reactor corresponding to about 3000 curies of fissions. Thus one could easily make 100 curies activity by irradiating a neutron absorber. In the "thermal column" where almost pure thermal neutrons are piped out one can obtain a flux of order 10^7 n/cm^2/sec.

MDDC-73 **Characteristics of Mixing and the Dilution of Waste Stack Gases in the Atmosphere, by** *P. E. Church, C. A. Gosline, Jr.* **16 p.**

A study has been made of the general characteristics of mixing and the amount of dilution that waste stack gases would experience when discharged into the atmosphere. It was assumed that such was dependent upon the meteorological conditions. Hence, for the experimental work, a 16-inch stack, 200 ft. high, was erected through which, by means of blowers, the whole discharge of an Army M-1 'smoke', (oil-fog) generator was ejected into the air. The stack was provided with 1-1/4 inch outlets at each 50 ft. interval (up to 150 ft.) through which came enough smoke to act as tracers for air flow at the various altitudes. These jet pipes extended outward 3 ft. from the stack; from each jet and at 200 ft. a shielded thermocouple was suspended and connected to a precision potentiometer in the nearby office building. Recording anemometers were placed at 16, and 60 ft. and a recording anemometer and wind vane at 200 ft. This instrumental arrangement provided data on the lapse rate, the wind velocity, the change of wind velocity, and the wind direction of the stack top.

A photoelectric instrument was designed and built. The instrument was based on the principle of exposure of a photoelectric cell to a light of fixed intensity between which was drawn the diluted oil-fog; any change of the light intensity caused by oil-fog droplets would vary the current output of the photoelectric cell. The 'photoelectric vapor densitometer' was extremely sensitive, rapid in action, and quite rugged. It was mounted in a truck capable of going over any type of terrain. The air with the diluted oil-fog was drawn continuously through the instrument by suction from the wind-shield wiper. The same type of instrument was used to determine the dilution when the oil-fog did not come to the ground except that the suction was produced by an aspirator device which operated when there was wind. The instrument and wires to the indicating meter on the ground were supported by a small barrage balloon.

Descriptions of testing and conditions are included.

MDDC-74 Elementary Theory of the Pile, by *E. Fermi*. 21 p.

Results and methods of construction and operation of a chain-reacting pile are discussed, based on the pile producing the first chain reaction at the Metallurgical Laboratory, University of Chicago.

Information is presented under the following headings: absorption and production of neutrons in a pile, life history of a neutron, probability of fission before slowing down, resonance absorption, probability of absorption at thermal energies, lattice containing a large number of cells, description of a graphite pile at Argonne Laboratory.

The lattice of the pile is also equipped with a number of holes in the shield and removable stringers of graphite that make it possible to explore phenomena inside the pile or to introduce samples for neutron irradiation.

MDDC-75 Direct Mass Assignments of 55-Day Strontium and 57-Day Yttrium, by *L. G. Lewis R. J. Hayden*. 8 p.

For the mass assignments reported here a sample containing the radioactive isotope of unknown mass number and also containing the normal stable isotopes of the same element was mounted in the sample holder of the mass spectrograph. The ion source converted a portion of the atoms of the radioactive isotopes and of the stable isotopes to positive ions These ions were then accelerated through electrostatic and magnetic fields in such a way that the ions of one mass only were brought to a focus at a given place on the collector. It was not sufficient that the ions merely produced a photographic image since this would not have differentiated a radioactive isotope from an isobar of a stable element. The ions of the radioactive isotopes remained on the collector thus producing a deposit which was located with a slit system and Geiger counter. The position of the radioactive deposit relative to the position of the stable isotopes thus determined the mass of the radioactive isotope.

The mass of 55-day strontium was assigned as Sr^{89} that of 57-day yttrium as Y^{91}.

The technique is described.

MDDC-76 Mass Spectrograph for the Analysis of Fission Product Mixtures, by *L. G. Lewis R. Hayden.* 17 p.

A mass spectrograph with 60° magnetic deflection giving 2.5 mass dispersion for one percent change in mass was developed for studies of radioactive isotopes formed in fission. The geometry of the ion accelerating electrodes and of the magnetic analyzer was chosen so that a maximum fraction of the ions formed by the source would reach the collector. It was possible to collect one ion for each 40 ions formed. An ion source using thermal emission of positive ions was found to possess several advantages for this work. Source efficiencies for conversion of atoms was very high for several elements (16 percent in the case of La) and the character of the emission was dependent on the chemistry of the elements. These emission data make it possible to identify not only the mass number of an isotope but also, in many cases, the element to which it belongs. The positions of the radioactive isotopes on the spectrograph plate may be located by means of a Geiger counter or by means of a "radio-autograph" of the spectrograph plate. This instrument and technique have been used primarily for the study of isotopes or rare-earth elements.

MDDC-77 Mass Spectrographic Identification of Active Isotopes Contained in Three Fission Product Mixtures, by *L. G. Lewis, R. J. Hayden.* 13 p.

The mass spectrograph described in MDDC-75 and 76 has been further improved and used for the mass assignments of fission products. A mechanism for the analysis of the spectrograph plates using a Geiger counter and slit system has been tested. This mechanism was found to be capable of good resolving power when fitted with slits of suitable geometry. The combination of these two instruments makes possible a study of the decay curves and the radiation energies from each of the several mass positions on the plate.

Experiments with a barium-lanthanum sample, a cerium sample, and a mixture of yttrium and cerium with other rare-earth elements are described. Results are discussed and tabulated.

MDDC-78 Total Cross Sections of Various Materials for Indium Resonance Neutrons, by *J. Marshall.* 4 p.

Measurements were made, using cadmium-filtered, boron-carbide-collimated neutrons from a 2" hole leading to the interior of the Argonne pile, of the total atomic cross sections of various substances for indium resonance neutrons. The collimation was such that no neutron scattered by more than about 6° was registered by the indium foil detector. The detector was shielded from thermal neutrons by thick cadmium and from stray epicadmium neutrons by thick shields of boron carbide. Background measurements were made by inserting an indium filter in the beam.

The observed cross sections in barns were: C - 4.84, Be - 6.10, D_2O - 10.30, H_2O - 44.4, Al - 1.46, BeO - 10.1, Pb - 11.39, BF_3 - 107, F (in C_7F_{16}) - 3.7.

In all cases but that of boron, the total cross section should be due almost entirely to scattering.

Assuming the indium resonance energy to be 1.44 electron volts and the scattering cross section of boron to be 2, the cross section of boron for neutrons of 2,200 meters per second velocity (kT at 293°K) is 710 barns.

MDDC-79 Beneficial Isotopes Available from Atom Bomb Project, by *G. O. Robinson, J. E. McKee, P. C. Aebersold.* 10 p.

News release published in full by *Science*, June 14, 1946 explaining the distribution program for radioactive isotopes.

MDDC-80 A Precision Alpha-Proportional Counter, by *J. A. Simpson, Jr.* 6 p.

An instrument is described which will detect and record the alpha-disintegration rate of prepared radioactive samples even though soft beta-radiation up to 5×10^9 disintegrations per minute may also be present. The resolution losses because of the detector, electronic amplifier, scaler, and recorder total 0.8 percent with an alpha-counting rate of 10^5 counts per minute. The instrument employs a proportional counter through which 99 percent CH_4 at one atmosphere slowly flows. The proportional counting region is approximately 300 volts in length with 0.5 percent change in counting rate in an interval of 200 volts. Thin radioactive samples deposited on metal disks up to 2.5 cm in diameter are easily inserted into the counter volume by means of a special gas lock. The counter detects 50% of the disintegrations from a thin radioactive sample. A linear amplifier with a band extending from 5×10^3 c.p.s. to 10^6 c.p.s. is used with a gain of 180 to amplify the alpha-pulses. The counter background can be maintained at about 14 counts per hour. A high vacuum, low geometry attachment provides reductions in geometry down to at least 10^{-5} of the sample counting rate. Some theory of gas flow proportional counters is presented along with details of the instrument construction.

MDDC-81 Pile Perturbation Theory, by *Harry Soodak.* 2 p.

The determination of the critical size and of the neutron distribution in a pile constitutes a characteristic value problem. Exact solutions are obtainable only for simple geometries and uniform pile structures. Other cases can be treated by perturbation theory in analogy to the Raleigh-Schroedinger method. The simplest case concerns the effect of localized absorbers. Their effect on critical size in simple piles turns out to be proportional to the square of the neutron density at the considered position which, suitably normalized, can be used as a statistical weight factor for irregular distributions. In the next approximation the distortion of the neutron distribution can also be evaluated. Other problems that can be treated are composite piles with parts of different properties, irregularities of shape of the pile, and the periods of non-critical piles. A systematic scheme for non-homogeneous piles involves the introduction of adjoint equation and solution for the neutron distribution in the pile.

MDDC-82 Calculation of Critical Size of Heterogeneous, Slow-Neutron, Chain Reactor, by *A. M. Weinberg*. 4 p.

The critical size of a large, slow-neutron, chain-reacting system is determined by the multiplication constant k, (average number of neutrons produced per neutron absorbed), and the migration length, (essentially the r.m.s. distance a neutron travels from birth as a fast neutron to death as a slow neutron). The multiplication constant is the product of $\eta\epsilon pf$. The calculation of f, the thermal utilization in a heterogeneous arrangement, is usually based on the following assumptions: (*a*) Wigner-Seitz cellular approximation is valid; (*b*) production of slow neutrons in moderator is constant over cell; and (*c*) first-order diffusion theory is applicable. The last assumption is incorrect, as stressed by Placzeck because the dimensions of the lumps are not large compared to the mean free path of the neutrons, and the absorption in the lumps is not negligible compared to the scattering The breakdown of diffusion theory implies that the angular distribution of neutron velocity vectors around a point must be represented by more than the first two spherical harmonics. It is found that the neutron density in the moderator is higher that that computed by first-order theory. This leads to a lowering of the first-order thermal utilization.

MDDC-83 A General Account of the Theoretical Physics Section in the Plutonium Project, by *E. P. Wigner*. 13 p.

Some of the early problems confronting the Plutonium Project group at the University of Chicago are discussed including Fermi's theory of the pile calculations for obtaining K_∞ and $K_{eff.}$ and effect of radiation on matter.

MDC-84 Regulated Supply, by *V S Allen* 1 fig

Electronic Circuit Drawing

MDDC-85 Linear Accelerator, by *L W Alvarez* 5 p.

Newspaper release giving popular description of the linear accelerator at the University of California

MDDC-86 A Semi-Quantitative Method for the Spectrographic Analysis of Small Samples of Powders, by *N. C. Bachelder*, 11 p

Microgram quantities of materials were burned to completion in a D C arc and the effects of constituent elements upon each other were eliminated making possible a semi-quantitative method of analysis

MDC-87 Sensitivity of Proton-Recoil Ionization Chambers, by *H. H. Barschall, H. A. Bethe.* 6 p.

In determining sensitivity of a Proton-Recoil Ionization Chamber, it is assumed that the scattering of neutrons by hydrogen is isotropic in the center of mass system. The sensitivities are determined for I - Gas Recoil Chamber of large volume, II - Chamber with thin Paraffin Radiator, III - Small Gas-Filled Chamber, IV - Chamber with Thick Paraffin Radiator. Equations and calculations are given for determining the sensitivities.

MDDC-88 The Crystal Structure of Polonium, by *W. H. Beamer, C. R. Maxwell.* 1 p. 1 fig.

Preliminary results of the investigations of various physical properties of polonium indicate that polonium undergoes a phase transformation at about 100°C. This was first discovered in measuring the thermal coefficient of electrical conductivity of thin polonium films. A plot of these data exhibits an abrupt decrease of electrical conductivity which is attributed to a phase change. This transformation has been further identified by X-ray diffraction powder photographs. For this work about 100 micrograms (0.5curie) of pure polonium were vacuum distilled into a capillary about 0.3 mm diameter and 0.01 mm wall thickness at residual gas pressure below 10^{-5} mm of mercury. The metal was concentrated in a short length of the capillary by two successive vacuum distillations in a closed system under a thermal gradient. The capillary was outgassed before use for about 20 hours at 425°C at 10^{-6} mm of mercury pressure. Diffraction patterns have been obtained of three samples using copper and iron radiation. Due to the lead formed by the radioactive disintegration of the polonium, the patterns change with time. This change is being followed in an effort to obtain knowledge of the Po-Pb system. The rate of formation of lead is approximately 0.5° per day. The photographs used for structure determination were taken from freshly prepared samples so that the lead content was less than 2%.

The crystal structure of polonium was studied by electron diffraction by Rollier, Hendricks and L. R. Maxwell. These workers interpreted the pattern obtained by transmission of thin films of polonium about 100Å thick as that of a monoclinic structure. Tabulations show data compared with their findings. A rough determination of density was made.

MDDC-89 Model 100 Delay Line Shaper by *N. E. Bradbury* 1 fig

Circuit diagram of instrument

MDDC-90 The Concentration of K^{39} and K^{41} by Balanced Ion Migration in a Counter flowing Electrolyte, by *A. K. Brewer*. 7 p.

The basic principle of operation of the method rests in an imposed flow of electrolyte through the cell at a rate sufficient to reduce the net transport of K^+ ions to zero Under this condition the faster-moving $^{39}K^+$ ions will make headway against the electrolyte stream toward the cathode compartment, while the slower moving $^{41}K^+$ ions will be carried back toward the anode compartment.

In the separation of electrolytic ions, where the transport can be looked upon as a small forward drift superimposed on kinetic agitation, it is necessary to reduce the rate of remixing in the electrolyte to a point below the rate of separation Also to obtain appreciable concentrations a multiple stage process must be employed Both these requirements have been met in the present experiments by carrying on the electrolysis in a fine-grained packing of uniform porosity The packing not only reduces remixing to a minimum but acts as a fractionation column operating under total reflux- Packings have been made of sand, glass wool, cotton glass beads etc

Calculations based on the assumption that the molar isotope transport equals the gain in concentration of the faster-moving isotope in the cathode compartment are presented The maximum value obtained for the separation coefficient was 1 0039• the average 1 0022. Changes of more than 50% in K^{39}/K^{41} were obtained

MDDC-91 Spiral Fission Chambers, by *W. C. Bright.* 19 p.

Neutron dectors utilizing thin metal foils coated with fissionable material are described. Foils are wound into concentric spirals to eliminate supporting plates and bulky insulation. The chambers are characterized by large useful electrode areas in small volume and by very light construction. A method is described for coating large areas of aluminum or platinum foil with heavy deposits of U_3O_8.

MDDC-92 Theory of Neutron Counters Using Proton Recoils from Paraffin, by *K. M. Case.* 36 p.

General methods of calculating bias curves for paraffin detector type neutron counters are developed. Using these techniques formulas are found for several special cases, including three counters used in the laboratory. Graphs indicating the cause of various undesirable effects and how they can be reduced are included. These may be of assistance in counter design. Various approximations of use in calculating the response of more complicated counters are indicated.

MDDC-93 **Half-Life of Uranium 234**, by *O. Chamberlain, D. Williams, P. Yuster.* 11 p

The half-life of U^{234} has been determined by two independent methods. The first method involves a re-measurement of the relative isotopic abundance of U^{234} and U^{238} in normal uranium; from this measurement the half-life of U^{234} can be obtained in terms of the known half-life of U^{238}. The value obtained by this method is $2.29 \pm 0.14 \times 10^5$ years. The second method involves the determination of the specific α-activity and relative isotopic abundances of several enriched uranium samples. The value obtained by this method is $2.35 \pm 0.14 \times 10^5$ years. Both values for the half-life are somewhat smaller than the currently accepted value of $2.69 \pm 0.27 \times 10^5$ years.

MDDC-94 **Room-Temperature Casting Resin for Mounting Metallographic Specimens**, by *J. S. Church.* 6 p.

This report describes the best-known method of preparing methyl methacrylate monomer for use as a room-temperature casting resin for mounting metallographic specimens for which ordinary methods involving heat and/or pressure are not satisfactory.

MDDC-95 Derivation of Equations (Taken from Project Handbook, CL-697, Chapter XII. C2.1), by *W. E. Cohn*. 1 p.

The toxic effect of internally deposited fission products is due practically exclusively to their beta radiation. Since the ranges of beta rays in tissue are small we may consider as an approximation that all the radiation emitted within a tissue is absorbed within that tissue. This leads to the following formula for converting curies of deposited radioactive sources into roentgens per day. In equation (1) I_i is the initial dosage rate in r/day.

In general, r/day = curies x (disintegrations/sec-curie) x (sec/day) x (ev/disintegration) x (ergs/ev) x (g-r/erg) x (1/g)

Hence, $I_i = Q_d \times 3.7 \times 10^{10} \times 86{,}400 \times E \times 1.6 \times 10^{-12} \times 1/84 \times 1/W$
$= 61\ E\ Q_d/W$

where W = grams of tissue absorbing radiation from Q_d
Q_d = curies deposited
E = average energy, in ev

The total dose D given to a tissue by the complete decay of such a source *in situ* (assuming no excretion) is

$$D = 61E\ \frac{Q_d}{W}\ \frac{1}{\lambda}$$

where λ = decay constant, in reciprocal days.

MDDC-96 Hydrogen Recoil Proportional Counter for Neutron Detection, by *J. H. Coon, R. A. Nobles.* 15 p.

A proportional counter utilizing recoiling protons ejected from a thin hydrogenous radiator by elastic collision with incident neutrons is described in its design and its response. Comparison between experimental and calculated curves for sensitivity versus neutron energy, and sensitivity versus counting bias indicate that the response of the counter is calculable. It may be used as a directional threshold neutron detector, the value of the threshold being open to arbitrary choice.

MDDC-97 Alloys of Gold and Beryllium, by *B. D. Cullity.* 13 p.+16 p. appendix

There are six intermediate phases in the gold-beryllium system: Au_3Be, Au_2Be, Au_4Be_3, AuBe, $AuBe_3$ and $AuBe_5$.

Satisfactory X-ray diffraction patterns of these phases were obtained, with the following results:

(a) Au_3Be, Au_2Be, and Au_4Be_3 each have symmetry lower than cubic.

(b) AuBe has a simple cubic structure.

(c) $AuBe_3$ and $AuBe_5$ are face-centered cubic; the former is partially disordered, the later completely ordered.

MDDC-98 The Willgerodt Reaction, by *W. G. Dauben et al.* 4 p.

Experiments prove that the Hofmann reaction is not a rearrangement and show that the Wolff rearrangement is an actual migration. They indicate that the Willgerodt reaction on acetophenone, giving both amide and acid, may go by at least two separate mechanisms, the acid arising from a path in which the phenyl group migrates. It is also seen that decarboxylation of phenylacetic acid with copper chromite catalyst may involve a more extensive decomposition.

MDDC-99 The Multiple-Wire Proportional Counter, by *B. Diven, R. W. Thompson.* 9 p.

A multiple-wire counter, consisting of a grid of fine wires mounted between plane screens, has been operated as a shallow, plane, proportional counter. Preliminary results on the characteristics of this detector with argon- CO_2 fillings are given.

MDDC-100 Half-Life of C^{14}, by *J. R. Dunning*. 3 p.

Improved counting techniques have been used with a mica-window Geiger counter tube to get a specific disintegration rate of some C^{14}-rich samples. The half-life was determined from this and the mass spectrometric measurements of the carbon isotopic abundances.

The measured activity was corrected for backscattering of the β-particles, self-absorption, and air and counter window absorption. The thickness of the absorbing layers was integrated over the emission solid angle measured to give the effective layer thicknesses using the method described by Reid. The absorption coefficient was determined independently by inserting filters between a C^{14} source and the counter. Sample I was a Na_2CO_3 solution (thickness > range of β - particles) prepared by quantitative absorption in NaOH solution of CO_2 generated from a $BaCO_3$ sample. Sample II was a sample of the Na_2CO_3 solution dried on an iron plate; the sample somewhat diluted with normal Na_2CO_3. Similar analyses on two other counters with varying absorption and geometry conditions checked within indicated experimental error.

CO_2 generated from another portion of the $BaCO_3$ was analyzed on a mass spectrometer. The spectrum showed a mole fraction of $C^{14}O_2$ of 1.71 ± .03%. Using the mean value of 2.46×10^5 disintegrations per second per mg. $BaCO_3$, calculation then gives the disintegration constant for C^{14} as 1.47×10^{-4} reciprocal years, equivalent to a half-life of 4,700 years. The precision of the complete measurement is probably from 5 to 10%. Thus 1 gram of C^{14} is equivalent to 515 curies or 200,000 rutherfords.

MDDC-101 10 M. C. Wide Band Amplifier and Scope, by *W. C. Elmore*. 1 fig.

Circuit Diagram of Instrument.

MDDC-102 Model 500 Amplifier, by *W. C. Elmore*. 1 fig.

Circuit diagram of instrument.

MDDC-103 Pre-Amplifier - Model 500, by *W. C. Elmore*. 1 fig.

Circuit Diagram of Instrument.

MDDC-104 Neutron Spectrum from a Cold Parahydrogen Radiator, by *T. Hall, F. DeHoffmann*. 15 p.

Some theoretical calculations are presented dealing with the type of neutron spectrum created when parahydrogen at 20°K is irradiated at a source of a high-energy neutrons like a cyclotron.

MDDC-105 Spin-Dependent Part of the Neutron-Deuterium Cross Section, by *T. Hall, F. DeHoffmann.* 9 p.

A matrix method for the spin-dependent part of the neutron-deuterium scattering cross section is worked out in detail. The method follows closely the treatment of Condon and Shortley for the evaluation of the dot product of matrices.

MDDC-106 1500 Volt R. F. Power Supply (Coil Data) , by *W. A. Hane.* 1 fig.

Circuit diagram

MDDC-107 1500 V. R. F. Power Supply, by *W. A. Hane* 1 fig.

Circuit diagram.

MDDC-108 R. F. High Voltage Power Supply (Voltage Doubler Type), by *W. A. Hane.* 1 fig.

Circuit diagram.

MDDC-109 R. F. Coil for R. F. High Voltage Power Supply (Voltage Doubler Type), by *W. A. Hane.* 1 fig.

Circuit diagram.

MDDC-110 Flat Response Neutron Detector, by *A. O. Hanson.* 13 p.

Tests have been made on three different detectors:

1) One, which consists of a B_4C-lined central detector 20 cm long and 3/4" in diameter surrounded by a cylinder of paraffin 20 cm long and 17 cm in diameter.

2) A detector lined with a thin film of U^{235} surrounded by the same amount of paraffin as above but also shielded by an additionall 1/2 " of paraffin and 1/2" of B_4C. This shield was to keep the counter from picking up neutrons scattered around the laboratory. This counter also has the advantage that its calibration is permanent since the fission pulses are easily detected and it is easy to be certain that practically all fissions are counted. It is hoped that this detector will be useful in determining relative neutron flux.

3) A more sensitive detector which is to be used with radioactive sources. The central part of this detector consists of a tubular ionization chamber 20 cm long and 1 1/2" in diameter which is filled with one atmosphere of BF_3. This detector is surfounded by a cylinder of paraffin 8" in diameter and 10" long.

These detectors will be referred to as detector 1, 2, and 3.

Efficiency of detection

The efficiencies for detection of RaBe neutrons by these three detectors are based on the neutrons which strike a paraffin face 7" in diameter. These efficiencies are .012 per cent, .0015 per cent and 0.5 per cent for detectors 1, 2, and 3, respectively. The highest efficiency counter filled with BF_3 is very convenient to use with radioactive neutron sources and gives about 800 counts per minute from a 200 mc RaBe source placed one meter from the face of the detector.

Although the results are somewhat qualitative, a summary is given for the different detectors. It should be remembered that detectors 1 and 3 are affected considerably by scattered neutrons and that the results might be affected by scattering material in the room in which it is used The results will be given in terms of the sensitivities of the various detectors to neutrons of different energies. These sensitivities are listed in the table below and are given as a percentage of the sensitivityto that at 1 Mev.

	Detector 1	Detector 2	Detector 3
Sensitivity to very high energy neutrons from RaBe	Low	Low	Good
Sensitivity to 0.2 to 2 Mev neutrons	100%	100%	100%
Sensitivity to neutrons of 5 Kev	85%	80%	80%
Sensitivity to 1 Kev neutrons	?	?	70%
Sensitivity to thermals	200%	130%	60%

(con't on next page)

MDDC-110 Flat Response Neutron Detector, by *A. O. Hanson.* 13 p. (Con't from Page 60)

The high sensitivities of detectors 1 and 2 for thermal neutrons are due to the fact that there is no cadmium shield over the front face of the central sensitive portion of the detectors. A cadmium shield was placed over this area in the third detector which reduces its sensitivity to thermals by a factor of 2. From the general behavior of these detectors one might conclude that detectors of this size and construction are quite flat in the region from 0.20 Mev to 2 Mev and that there is a decrease in the sensitivity for the lower energy neutrons. The sensitivity is probably around 75 per cent for 1 to 10 Kev neutrons. It might be possible to increase the relative sensitivity to the slower neutrons by changing the paraffin geometry around the central detector or by suitable use of additional absorbers or detectors placed inside the paraffin.

MDDC-111 Pulse Analyzer - 1 Channel by *W. Higinbotham.* 1 fig.

Circuit diagram.

MDDC-112 Scale of 64 and Discriminator, by *W. Higinbotham.* 1 fig.

Circuit diagram.

MDDC-113 Scale of 64 with R. F. Power Supply - Model 400 by *W. Higinbotham.* 1 fig.

Circuit diagram.

MDDC-114 Scaler Unit Circuit, by *W. Higinbotham.* 1 fig.

Circuit Diagram.

MDDC-115 Efficiencies of Neutron Counters Using Recoils of Protons in Argon and Xenon, by *J. O. Hirschfelder, J. L. Magee.* 44 p.

Range energy curves for protons in glyceryl tristearate ($C_{57}H_{110}O_6$), paraffin $(CH_2)_x$, argon, and xenon are presented. The Bethe theory was used to calculate the stopping power of protons in C, H, O, A, and Xe. Differential bias curve and counting efficiencies have been calculated for neutron counters forming proton recoils in glyceryl tristerate and using argon and xenon for stopping these protons. The methods used are given in some detail in the report.

MDDC-116 Ratio of 60 Pulse Generator Mark 21, Model 3 A, by *W. P. Jesse.* 3 p.

Circuit diagram and description of instrument.

MDDC-117 Survey Instrument, Mark 1, Model 10, Zeuto, by *W. P. Jesse.* 3 p.

Circuit diagram and description of operation is given. Photographs of the instrument are also included.

MDDC-118 Survey Instrument, Mark 1, Model 21-A, Zeus, by *W. P. Jesse.* 3 p.

Circuit diagram and description of the instrument, are given. Photographs of the the instrument are included.

MDDC-119 **Metallographic Preparation Method for Tungsten Carbide**, by *G. L. Kehl*. 6 p.

The following preparation procedure has been developed for tungsten carbide, making liberal use of different particle-size diamond dust and the use of a new type diamond lap.

1. Secure a flat surface on the metallographic specimen by cutting off a small portion of the sample on a water cooled cut-off machine. A cut-off wheel suitable for this purpose is a 1/16-inch thick, 10-inch diameter, metal bond diamond wheel No. 100-M. Cutting with this grade of diamond wheel produces a roughness of surface that is readily removed by the first grinding operation described below. The cutting-off technique is applicable to specimens either unmounted or mounted in bakelite provided a suitable holding fixture is available

2. Grind the specimen on four successive diamond laps, each rotating at approximately 175 RPM. A design of lap found to be excellent for this purpose consists of an 8-inch micarta (or metal) disc over which is placed a circularly cut sheet of tracing paper No. 353B . The paper sheet is held into position by means of a ring fitting around the periphery of the micarta disc. Each lap is charged respectively with diamond dust of decreasing particle size - No. 2 (74 microns), No. 4 (37 microns), No. 7 (5 microns), and No 8 (2.5 microns) - and added onto the lap in an amount equivalent to that which can be retained on the end of a moistened toothpick. The most satisfactory lubricant is oil of lavender, applied to the lap by means of a medicine dropper. The surface of the laps during use are never permitted to become dry, nor is the amount of lubricant added sufficiently great to make the lap excessively wet.

Tungsten carbide specimens may be satisfactorily etched for particle size determination in a reagent consisting of one part of a 5% potassium hydroxide solution and three parts of 5% solution of potassium ferricyanide. Manufacturers are specified.

MDDC-120 Remarks Concerning X-Ray Pulse and Photographic Film Technique of Recording X-Ray Pulse Pictures, by *D. W. Kerst.* 1 p.

The duration of the x-ray pulse of the betatron is less than 1/2 microsecond and the burst of x-rays produced by it can be used for taking single pulse x-ray photographs as is done with the Westinghouse pulsed x-ray equipment. An extremely fast photographic technique using Eastman W-screens and Industrial F film is required.

MDDC-121 Note on Performance of an Experimental Spray Scrubber, by *R. Landau.* 3 p.

The spray tower used in the runs was 4" in diameter and about 5' high. Inside there were four nozzles spaced 1' apart along the longitudinal axis. The tower was fed with 15% potassium hydroxide solution at a total rate of approximately 1.5 G.P.M. The solution was distributed equally between the four nozzles. Consequently, the liquid rate varied from 9600 lbs./hr./sq.ft. at the bottom of the tower to 2400 lbs./hr./sq.ft. at the top. Since the effectiveness of a nozzle falls off rapidly with increasing distance from it, it is probable that the maximum effective flow rate of liquid is closer to the latter value than the former.

The gases fed to the scrubber were 5% mixtures of either fluorine or carbon dioxide in nitrogen, at a rate of 5 cu.ft. per minute. The exit gas concentration was measured by passing a continuous sample through a train of three sintered glass bubblers immersed in strong caustic and potassium iodide solution (in the last bubbler) The difficulties in the experimental measurements were such that the precision of the exit gas analysis was not great. However, the concentration of the exit gases in the case of fluorine was between 0.1 and 0.5% and in the case of carbon dioxide was about from 0.6 to 0.8%.

Since there is no back pressure of gas over the solution, the use of a logarithmic mean driving force is permissible, and an overall absorption coefficient $K_G a$ (lb. mols/hr./cu.ft./atmosphere driving force) has been calculated. Its value is 4.9 to 9 for the case of fluorine and 3.7 to 4.3 for the case of carbon dioxide. The probable value for both cases is 4 to 6.

MDDC-122 Paraffin Thickness Correction for Neutron Counters Using Recoil Protons and Deuterons, by *J. L. Magee.* 7 p.

The neutron counter using recoil protons or deuterons in a rare gas, collecting only electrons, and having a Frisch grid makes possible the study of angular distribution of recoil particles. The correction for the thickness of the paraffin film used for scattering the neutrons must be made for an accurate determination of the angular distribution function. The paraffin range-energy relation calculated in report MDDC-115 has been used to develop a method to correct for the film thickness. The resulting formula is explained and the derivation is presented.

MDDC-123 Elastic Backscattering of d-d Neutrons, by *J. H. Manley et al.* 14 p.

The backscattering of d-d neutrons was investigated for several materials. A directional thick paraffin was used. The detector was sensitive primarily to neutrons which had been scattered elastically orwith little energy loss.

MDDC-124 **Production and Isotopic Assignment of a 90-Day Activity in Element 43, by** *E. E. Motta, G. E. Boyd, A. R. Brosi.* **1 p.**

Experiments have been carried out wherein growth was observed of a daughter activity formed by K-capture decay of a previously discovered three day Ru^{97} isotope. Extensive chemical tests in which the known, six-hour 43^{99} activity was employed as a monitor have shown this daughter activity to be an isotope of element 43, thus permitting its assignment to 43^{97}. The activity has been observed to decay with a half-life of 93 ± 5 days over three months time. The radiations have been found to consist largely of very soft electrons of 1.5 mg/cm^2 half-thickness in Al, along with possibly a small amount of unconverted gamma radiation and probably X-rays. The half-period and character of the radiations possessed by this 43 isotope suggest that its activity is the same as that observed by Cacciapuoti and Segre from the deuteron bombardment of molybdenum.

MDDC-125 **Absorption of Slow Neutrons by Cd^{113}, by** *B. J. Moyer, B. Peters, F. H. Schmidt.* **1 p.**

The isotopes of cadmium were separated by a mass spectrograph and the absorption of thermal neutrons in Cd samples of different isotopic composition was studied. The solution prepared from a sample of cadmium enriched in isotope 113 gave a cross section for absorption six times larger than a solution of equal concentration containing cadmium of normal isotopic composition. The absorption in solutions containing cadmium enriched in Cd^{106}, Cd^{108}, Cd^{110}, Cd^{111}, Cd^{112}, Cd^{114} proved to be very small compared to the absorption in normal cadmium. The capture cross section for thermal neutrons in Cd^{116} is known to be small (1.4 barns.)

The authors conclude that the large absorption cross section of cadmium for thermal neutrons is due to resonance capture in Cd^{113} (whose natural abundance is 12.3%) and that none of the other cadmium isotopes make any appreciable contribution.

MDDC-126 Pure Beryllium Oxide as a Refractory, by *F. H. Norton.* 14 p.

A description is given of some beryllia refractories, particularly those of high purity and very low porosity. Interesting properties of this material are its great hardness, high thermal conductivity, and stability.

MDDC-127 Geometrical Formulas for Experiments on Single Scattering, by *P. Olum.* 8 p.

Author assumes a point source of neutrons, a point detector of neutrons, and a thin scatterer in which only single scattering occurs. Formulas are derived for the number of counts per second which will be given by the detector, in terms of the source intensity (as a function of direction), the scattering cross section of the scatterer, and the geometry of the arrangement; this last factor is the one with which the report is primarily concerned. A comparatively simple expression is derived for the relative amount by which any scattering angle θ is weighted due to the geometry of the experiment. These formulas are derived for the general case and also for surfaces of revolution, including, as a special case, the disc.

MDDC-128 Counting Rate Meter - Model 200, by *N. Sands*. 1 fig.

Circuit diagram of instrument.

MDDC-129 Counting Rate Meter - Model 100, by *N. Sands*. 1 fig.

Circuit diagram.

MDDC-130 Ion Gauge Control, by *N. Sands*. 1 fig.

Circuit diagram.

MDDC-131 Model 100 Amplifier, by *N. Sands*. 1 fig.

Circuit diagram.

MDDC-132 Model 100 Precision Pulser, by *N. Sands*. 1 fig.

Circuit diagram.

MDDC-133 Oscillograph Circuit, by *N. Sands*. 1 fig.

Circuit diagram.

MDDC-134 Stopping Power of Various Substances for Fission Fragments, by *E. Segre, C. Wiegand.* 12 p

The relative stopping powers of some materials were determined for fission fragments for U^{235} and for 4.66-Mev α - particles. The results:

	Mass Stopping power		Atomic stopping power	
	α	f	α	f
Collodion	1.38	1.70	..	..
Al	1.	1.	1.	1
Cu	0.69	0.66	1.59	1.52
Ag	0.51	0.55	2.04	2.20
Au	0.36	0.34	2.62	2.48

MDDC-135 Amplifier, Preamplifier, by *H. Staub.* 1 fig.

Circuit diagram of instrument.

MDDC-136 Discriminator-Pulse Generator, by *H. Staub.* 1 fig.

Circuit diagram of instrument.

MDDC-137 Double Scope Supply, by *H. Staub.* 1 fig.

Circuit diagram of instrument.

MDDC-138 MW Counter Drawings 1A to 6A, by *H. Staub.* 6 fig.

Drawings of Instrument.

MDDC-139 Step Calibrator, by *H. Staub.* 1 fig.

Circuit Diagram of Instrument.

MDDC-140 **Mass-Assignment of 2.6 h Ni^{65}.** by *J. A. Swartout et al.* 3 p.

Approximately 100 mg of each of two copper samples enriched in Cu^{65} and in Cu^{63} by the calutron were obtained from the magnetic separation plant. The enriched samples were purified chemically by three electrolyses from a H_2SO_4 - HNO_3 electrolyte using platinum electrodes, and then dissolved in purified nitric acid and conductivity water. Mass-spectrographic analyses indicated the following isotopic abundances in the samples.

Sample 1: 93.1 ± 0.5% Cu^{65}, 6.9 ± 0.5% Cu^{63}

Sample 2; 3 ± 1 % Cu^{65}, 97 ± 1% Cu^{63}

In order to establish the mass of the 2.6 h Ni isotope, comparisons were made of intensities of the nickel activity obtained from (n,p) reactions on each of the enriched copper samples placed in the neutron field of the chain-reacting uranium pile. Because of the low activation cross section expected for the (n,p) reaction compared with that for an (n,γ) reaction, it was necessary to eliminate the possibility of traces of nickel impurity in the copper. Assurance of freedom from nickel contamination was obtained by repeated bombardments in the pile at constant neutron flux of the same copper samples followed by chemical isolation of nickel after each bombardment.

The apparent specific beta activities of the 2.6 h Ni obtained from the first one or two bombardments were erratic due probably to nickel impurity in the copper and to the presence of longer lived beta activities believed to be from Pt^{197} which resulted in complex decay and absorption curves. However, in the nickel fractions from subsequent bombardments, the amount of the 2.6 h Ni beta activity was proportional to the amount of Cu^{65} bombarded, as is illustrated by data from one bombardment of enriched Cu^{63} and enriched Cu^{65}.

Evidence for the Production of 2.6 h Ni by the Reaction: Cu^{65} (n,p) Ni^{65}

	Sample 1	Sample 2
Weight of Enriched Cu Sample Bombarded (mg)	48.8	27.4
Weight of Cu^{65} - (Based on Mass-Spectrograph Analysis)	45.2 to 45.7 mg	0.55 to 1.1 mg
Total 2.6 h beta activity-(c/m at 100% geom.)	1.5×10^6	1.7×10^4
Specific Activity-(c/m/mg Cu^{65} at 100% geom.)	3.4 to 3.3×10^4	3.1 to 1.5×10^4

The characteristics of the beta activity agreed with those previously reported in that the half-life was within the limits of 2.5 to 2.7 h, and the energy as determined by Feather analysis was 1.9 to 2.0 Mev.

MDDC-141 **Beta Rays from H^3**, by *R. J. Watts, D. Williams.* 9 p.

The upper limit of the β ray spectrum of H^3 has been re-determined by a method involving the acceleration of β-particles through a thin window into a Geiger counter. The effective window thickness was determined by acceleration of electrons from a hot filament. The value obtained for the upper limit is 11 ± 2 kev.

MDDC-142 **The Preparation of Polyperfluorovinylchloride**, by *E. A. Belmore, W. M. Ewalt R. L. Murray.* 27 p.

This problem in its general scope consisted of the preparation of an oil with limited physical properties and possessing a very high chemical inertness.

The process for the preparation of polyperfluorovinylchloride consisted essentially of four steps or chemical reactions.

1) Step I - Preparation of the Monomer

$$CF_2Cl - CFCl_2 + Zn \xrightarrow{\text{Ethanol}} CF_2 = CFCl + ZnCl_2$$

1.2.2-trichloro-1.1.2-trifluoroethane perfluorovinylchloride

The trichlorotrifluoroethane is added slowly to a suspension of finely divided zinc in ethanol. The reaction readily takes place at 60 - 70°C and the evolved gas is passed into a suitable low temperature fractionating column. Here the pure monomer is removed from the top of the column and any alcohol or unreacted starting material is returned to the reaction vessel. The perfluorovinylchloride boils at -27°C and it must be stored at temperatures well below this or in suitable pressure vessels

2) Step II - Polymerization of the Monomer

$$CF_2 = CFCl + \text{Benzoyl Peroxide} \xrightarrow{CHCl_3} (CF_2\text{-}CFCl)_x$$

Crude polymer

The pure monomer is dissolved in about nine times its own weight of alcohol-free chloroform, which contains benzoyl peroxide in quantities of about 5 to 8 per cent of the weight of monomer. This solution is then heated in a pressure vessel for 1-3/4 hours at 100°C. At the end of the reaction the autoclave is cooled and the unreacted monomer and chloroform are then removed by distillation leaving behind the crude polymer. This is a heavy, tan colored material resembling cup grease in appearance. The polymer is further concentrated and some of its unstable components are removed by heating under partial vacuum to 140 - 150°C while passing through it a stream of air. The remainder after this treatment is distilled under an absolute pressure of 1 mm. or less. Up to 120°C. there is collected a clear light oil which is too volatile and too low in viscosity to meet specifications. From 120° to 240°C when the distillation is stopped, product is collected which ranges from a medium oil to a semi-solid wax. All this cut is blended for further processing. The residue remaining is fluid when hot, but an amber colored resin-like solid at room temperature.

3). Step III - Preparation of Cobalt trifluoride

$$2CoF_2 + F_2 \longrightarrow 2CoF_3$$

Cobalt trifluoride is needed for the following step and it is prepared by treating anhydrous cobalt difluoride with elemental fluorine at temperatures up to 200 - 250°C. It is very desirable to have the finished salt contain a maximum of the active trifluoride and a minimum of the inactive difluoride.

(con t on next page)

MDDC-142 The Preparation of Polyperfluorovinylchloride, by *E. A. Belmore W. M. Ewalt, R. L. Murray.* 27 p. (con't from page 72)

4) Step IV - Stabilization of the Distilled Polymer

$$(CF_2 - CFCl)_y + CoF_3 \longrightarrow (CF_2 - CFCl)_z + CoF_2 + HF + Cl_2$$

The hydrogen atoms present in the end groups of the polymer chains (chloroform benzoyl, or benzene radicals) as well as any unsaturation are removed or rendered inactive by treatment with cobalt trifluoride. The distilled polymer is mixed with successive portions of CoF_3 at temperatures from 100° to 200°C until a total weight of CoF_3 equal to the weight of polymer has been added. Considerable gas is evolved during this treatment and the reaction can be quite violent unless the proper precautions are observed. The stabilized polymer is extracted from the spent salt with carbon tetrachloride filtered, concentrated, and redistilled. The fraction boiling between 100° and 200°C at 0.2 mm. is collected as the finished polymer. This process was modified and applied to plant production.

MDDC-143 Excitation of Plasma Oscillations, by *D. Bohm.* 4 p.

A theory of plasma oscillations has been developed for conditions in which special groups of electrons moving with much higher than thermal speeds are present. The first case considered was that of a beam of fast electrons injected into the plasma from a cathode. If the electron velocity is slightly above the phase velocity of the plasma wave, the electron beam loses kinetic energy to the wave, which is therefore excited. The maximum amplitudes of oscillation for given conditions can easily be calculated. The second case studied was that of a plasma containing a group of fast electrons, moving in random directions such as might be generated in the process of ionization. Excitation of plasma waves here is the result of the drop in wave velocity with dropping plasma density as the boundary surface is approached. Such a wave can abstract energy from electrons of a wide range of velocities, and thus provide an additional mechanism for bringing the system to equilibrium. The excitation of such waves is offered as an explanation of the anomalous scattering of fast electrons in a plasma, and of the unexpectedly rapid rate at which electrons come to the Maxwellian distribution

MDDC-144 Resistance of Materials to Fluorine and Hydrogen Fluoride, by *N. H. Brown*. 4 p. 1 fig.

The indicated suitability of various metals and alloys in fluorine based on short time tests, is as follows:

Nickel appears to be quite resistant up to 900°F and probably to about 1000°F Results on Monel are more erratic and generally higher than those on nickel and it probably should be rated 50-100°F. lower in limiting temperature for useful service Inconel is considerably less resistant and is definitely unsuitable at 750°F, the lowest temperature at which it was tested. Copper is more resistant to fluorine than to chlorine and has proved quite useful in service although it is inferior to either nickel or Monel The corrosion rates obtained in tests on copper were higher than those observed in practice. This is believed to be explained by traces of oxygen in the gas used, since it was observed that the coating formed on copper was at least partially oxide. 2S aluminum was essentially unaffected under test conditions up to 850°F and neglecting mechanical limitations, could probably be used at somewhat higher temperatures. Dow Metal G was unattacked up to about 575°F. The stainless steels do not show up at all well in fluorine all grades tested being quite badly attacked above 400-500°F.

With reference to hydrogen fluoride nickel was only slightly attacked at 1100°F Only one of six specimens of Monel exposed between 930 and 1110°F, showed appreciable attack and the same was true of deoxidized copper. Inconel was less resistant than nickel or Monel under the test conditions and probably should not be used above 900°F. It should be noted that commercial anhydrous hydrogen fluoride sometimes contains sulfur compounds and it has been found that if this is the case, typical and severe sulfide attack can be expected in high-temperature operation on all of these materials Tests on 2S aluminum gave results comparable to those in fluorine and a single run on Dow Metal G at 930°F resulted in a slight gain in weight. A few runs in Types 304 347, 309-Cb, 310-Cb, and 430 stainless steel showed all to be quite badly attacked at 1000°F. Single runs at 930°F, on these materials indicated a high corrosion rate for Type 347, gains in weight for 309-Cb and 310-Cb, and a slight loss in weight for Type 430.

MDDC-145 Carcinogenic Action of Some Substances which may be a Problem in Certain Future Industries, by *A. M. Brues, H. Lisco, M. Finkel.* 18 p

Experiments were set up to observe the effects of radioactive Sr^{89}, Ce^{144}-Pr^{144}, Y^{91}, and plutonium. Radium was also studied for comparison with earlier human and animal work. Sprague-Dawley rats, Carworth CF-1 and ABC hybrid mice, and a few C58 mice as well as rabbits and dogs were used. All animals received complete autopsy terminal blood study, and roentgenograms.

Sr^{89}, with a 55-day half-life has a tendency to concentrate in bone The energy of its beta particles is such that its energy is largely dissipated within 1/2 mm of the site of deposition. Thus, bone, bone marrow, and the immediate surrounding tissues are the site of virtually all of the irradiation damage. Sr has no visible effect on mammary tumor incidence and a slight positive effect on lymphoma incidence. It is a producer par excellence of bone tumors. Analysis of bone tumor incidence in a series of over 3 000 mice, 400 to 500 days after treatment, shows that expectance of tumor development is approximately proportional to dose and to time after the onset of a 'latent period' but that the latent period itself is a function of dose which increases only gradually (perhaps logarithmically) with decreasing dose. Such a scheme is shown to fit, as well as can be determined, the existing human radium data. It appears that age of the animal at the time treatment is administered has little effect on latent period of tumor expectancy, even when the isotope is absorbed by the growing fetus.

Radium, in addition to bone tumor induction, produces heavy calcification in the media of the larger arteries and in certain other sites.

Radioactive cerium - praeseodymium, which gives an initial high liver concentration, causes atrophy of this organ except in the marginal areas, where ionization is less and regeneration can proceed. Bone sarcoma is also produced.

Yttrium^{91}, which was fed by stomach tube, is virtually unabsorbed. One-tenth of the acute lethal dose can be fed easily for 3 months with no measurable detriment. Animals surviving this treatment, as well as those surviving a single acute dose of 20 to 30 mc. per kgm . show after several months a variety of intestinal lesions with obstruction.

Plutonium (Pu^{239}), when injected intravenously, has its highest immediate concentration in liver and spleen, and is later translocated to bone. Acute plutonism is similar to acute total body radiation sickness, with the additions of splenic atrophy and gross liver changes. Chronic plutonism involves greying of hair, progressive liver damage, and bone sarcoma. Following subcutaneous injection of 1 μgm. of plutonium, local fibrosarcomas may appear within a year. Local epilations, ulceration, keratosis, and spontaneous amputation are also seen.

MDC-146 Document Requesting Declassification of Fluorocarbons, by C. E. Center. 2 p. 18 fig.

The document comprises a request to declassify the following materials:

Formula	Chemical Name
C_2F_3Cl	Trifluorochloroethylene
$(C_2F_3Cl)_x$	Polymerized trifluorochloroethylene M.W. ~ 600
$(C_2F_3Cl)_x$	Polymerized trifluorochloroethylene M.W. ~ 900
$(C_2F_3Cl)_x$	Polymerized trifluorochloroethylene M.W. ~ 1400
$(C_2F_3Cl)_x$	Polymerized trifluorochloroethylene M.W. ~ 1200
$(C_2F_3Cl)_x$	Plasticized trifluorochloroethylene
$(C_2F_3Cl)_x$	Plasticized trifluorochloroethylene
C_7F_{16}	Completely fluorinated n-heptane
C_7F_{14}	Completely fluorinated ethyl cyclopentane
C_7F_{14}	Completely fluorinated methyl cyclohexane
C_8F_{16}	Completely fluorinated meta-dimethyl cyclohexane
C_9F_{20}	Completely fluorinated nonane
$C_{10}F_{22}$	Completely fluorinated decane
$C_{11}F_{24}$	Completely fluorinated hendecane
$C_{12}F_{26}$	Completely fluorinated dodecane
$C_{13}F_{28}$	Completely fluorinated tridecane
$C_{21}F_{44}$	(empirical formula)

General properties of C_7F_{16} and C_8F_{16} are listed

MDDC-147 **Magnetic Fields Due to Dee Structures in a Synchrotron** by *A. F. Clark.* 4 p.

Eddy currents in the synchrotron were found to cause magnetic fields which disturbed the orbits of the electrons. To decrease the eddy currents, experiments were undertaken to determine the size of the effects and to arrive at a more appropriate design for the dee structures. The rf electrodes (dees) in the synchrotron were therefore laminated, i e. made of separate wires.

Since the fields are brought about by complicated structures, together with their image currents in the iron pole pieces, effects were measured rather than calculated. (For methods of measuring see MDDC-174) However effects were calculated for two circular disks and checked by measuring For the more complicated structures, also, only qualitative calculations were completed. It was also found that 'non-magnetic' stainless steel had sufficient permanent magnetism to affect the out-of-phase field measurements. The field as a whole is decreased but can be increased by a d c. winding around part of the yoke. The variation of the vertical field with radius is changed, and horizontal field components are added The measurements were checked by observing the time of reversal of flux in small permalloy strips, sometimes called peaking strips , placed at different points in the magnetic field. The difference in the time of reversal between two points in the magnet multiplied by the rate of change of the field gives the difference in the magnetic fields at the two points due to the out-of-phase components Results are tabulated peaking strip circuits are diagrammed, and curves are plotted to indicate variables in the magnetic field due to eddy currents

MDDC-148 **Efficiency of Frequency Modulated Cyclotron**, by *L. Foldy, D. Bohm.* 10 p.

In the frequency-modulated cylotron (or synchro-cyclotron), the loss of resonance resulting from relativistic increase of mass is overcome by capture of particles into phase stable orbits, (1) (2) the energy of which is adiabatically increased by a slow decrease of frequency of the dee voltage There is, however, only a small fraction of the cycle of frequency modulation during which ions can be captured into phase stable orbits with phase oscillations of amplitude small enough to prevent particles from ever being returned to the origin By solving the phase equation (2) authors have obtained general expressions for this fraction which may be called the 'efficiency' relative to that of a normal cyclotron For conditions which may be realized in the 184" cyclotron to be built at Berkeley, the maximum efficiency is about 5%

(1) E. McMillan Phys Rev 68, 143 (1945)
(2) V. Veksler, J Phys. (USSR) 9, No 3 153 (1945)

MDDC-149 Energy of Neutrons from MsTh-D, Y-Be, and Sb Be Photo-Neutron Sources by *A. O. Hanson.* 21 p.

The energies of neutrons from several photo sources have been compared with that of neutrons of known energies from the Li (p,n) reaction by observing the maximum pulse heights of proton recoils in a hydrogen-filled proportional counter. The results are shown in the following table.

Sources	MsTh-D	MsTh-Be	Y-Be	La-D	Sb-Be
Measured Maximum Energies	223 ± 10	830 ± 30	162 ± 7	174 ± 8	26 ± 5
Average Energies	195 ± 10	818 ± 30	158 ± 8	149 ± 8	25 ± 5

The values found are consistently lower than that expected from the measured gamma-ray energies. This suggests that there may be some systematic errors in these measurements or in previous work. Better agreement could be obtained if the values of the photo-thresholds of deuterium and beryllium were made slightly higher than that previously reported.

The comparison of the energies of the protons from La and MsTh gamma rays on deuterium give an accurate determination of the energy of most energetic gamma rays from La. This value is 2.52 ± 0.010 Mev.

MDDC-150 The Preparation of Fluorine. by *Harshaw Chemical Co.* 14 p.

A commercially practical fluorine cell of the diaphragm type drawing approximately 1,000 amperes has been developed. Ordinary carbon steel is suitable for the major parts of this cell, including the cell body, the hot water jacket, the hydrofluoric acid feed line, the cathode, and the solid part of the diaphragm. The anodes are carbon rods impregnated with copper. The lower portion of the diaphragm is a monel screen.

The electrolyte is fused KF-2HF with 1.0 to 1.5% lithium fluoride as an additive. The cell operates at 95 to 115° C. with an anode current efficiency close to 95% and an overall potential drop of 9.0 to 9.5 volts. Such large cells have operated continuously with very little attention for more than thirteen months.

Drawing on the experience gained with the large cell, a 50-ampere laboratory cell which generates close to 35 g. fluorine per hour has been constructed. Although extensive life data are not yet available, it now appears that the small cell will be equally as satisfactory as the large one.

MDDC-151 Synchrotron Radio Frequency System, by *A. C. Helmholz, J. V. Franck, J. M. Peterson.* 7 p.

The 47.7 mc radio frequency system for the 300 Mev Berkeley synchrotron is described. The electrons will be accelerated both on entering and on leaving a laminated C shaped electrode, occupying approximately 135 degrees of the electron orbit. The electrode is supported by six coaxial lines, extending radially outward. Five of these lines are terminated at the voltage nodes by ground planes, and the stubs thus formed are tuned over a small frequency range by means of rotating paddles which vary the inductance. The sixth line is electrically a half wave length. It couples the radio frequency power from the grounded grid type oscillator using a medium mu water cooled triode to the accelerating electrode. Radio frequency excitation for the filament of the tube is obtained from a tap near the node of the half wave-length line. This coaxial line is folded so that the tap point is physically close to the filament and forms with the oscillator a compact structure. The necessary pulsing of the oscillator is discussed.

MDDC-152 Absorption in a High Molecular Weight Non-Aqueous System - Uranium Hexafluoride in Heavy Oil, by *R. Landau, D. E. Birchenall, G. G. Joris, J. C. Elgin.* 46 p.

In connection with the industrial design of a system for the absorption from inert gases of uranium hexafluoride (molecular weight 352) by a special heavy oil (molecular weight 750), an attempt was made to check the validity of established techniques of calculation (modified to some extent) by a limited experimental program. Making use of the generally accepted theory, and extrapolating the data available for the common absorption systems, the performance to be expected in the present system was first predicted. The experimental study in a small scale packed tower followed. Since the molecular weights and associated properties for this non-aqueous system differed very widely from published data for other systems (mostly aqueous), and since the temperature of operation (200°F.) was also beyond the range of most available data, it was felt that the results of this study would provide a severe critique of existing design methods and lend some confidence to their use in similar cases in the future. This paper presents a summary of the results obtained in graphical and tabulated form.

In the countercurrent absorption of gases by liquids, or the reverse operation of stripping, it is generally assumed that the controlling mechanism (in the absence of chemical reactions) involves diffusion across two stagnant fluid films at the phase interfaces, these films being gas and liquid. The quantitative application of the two-film theory of absorption has been described in the literature. In the case of a system following Henry's law,

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MDDC-152 Absorption in a High Molecular Weight Non-Aqueous System - Uranium Hexafluoride in Heavy Oil, by *R. Landau, D. E. Birchenall, G. G.Joris, J. C. Elgin.* 46 p. (cont'd from page 79).

$$\frac{1}{K_G a} = \frac{1}{k_G a} + \frac{1}{H k_L a}$$

where, $K_G a$ overall absorption coefficient, lb. mols/hr. x cu. ft. x atm.
$k_G a$ gas-film absorption coefficient, lb. mols/hr. x cu. ft. x atm.
$k_L a$ liquid-film absorption coefficient, lb. mols/hr x cu. ft. x (lb.mols/cu.ft.)
H Henry's law constant, lb. mols/cu.ft. x atm.

If information is available to permit calculations of the individual film resistance, then the overall coefficients may be calculated for various conditions and the apparatus properly designed. If Henry's law does not hold, then this equation can only be used differentially at points in the apparatus.

Sufficiently good agreement between theory and experiment have been obtained to suggest that the design technique employed in this paper may be of considerable value in the absence of direct data, but that a substantial amount of coordinated work is still required to establish engineering design of absorption and stripping equipment on a sound and accurate basis. There is also encouraging evidence that small-scale experiments can be extrapolated to plant-scale operation if the underlying correlations can be strengthened along the lines suggested.

MDDC-153 Continuous Fluorine Disposal Plant, by *R. Landau.* 16 p.

Waste fluorine can be disposed of by absorption in caustic soda solutions of strengths greater than about 2%. However, due to the limited solubility of sodium fluoride in water or caustic solutions, erosion and plugging of equipment may result. Although the potassium fluoride is much more soluble, potassium hydroxide is more expensive. Consequently, a plant was designed employing caustic soda equipped with continuous chemical regeneration, so that the sodium fluoride concentration was always kept below the solubility limit. This chemical regeneration was accomplished by continuous treatment with lime slurry, which precipitated calcium fluoride, and regenerated the caustic soda:

$$F_2 + 2NaOH = \tfrac{1}{2}O_2 + 2NaF + H_2O$$

$$2NaF + CaO + H_2O = CaF_2 + 2NaOH$$

In this manner, the caustic concentration was maintained constant, and the calcium fluoride could be removed continuously from the system by gravity settling.

MDDC-154 Industrial Handling of Fluorine, by *R. Landau, R. Rosen.* 42 p. (See Also *Industrial and Engineering Chemistry,* vol 39, P. 281-3, March 1947).

A survey is given of some of the properties of fluorine and recent developments on its handling in laboratory and commercial practice.

General properties are discussed. For example, fluorine is the most reactive chemical element, being found at the extreme end of the electromotive series with a potential of -2.85 volts. Its atomic weight is 19 and its atomic number 9. It is a gas at normal temperatures and pressures. Physical characteristics are tabulated. A discussion of the physiological properties of fluorine is limited to the exposure to concentrated and relatively large amounts of fluorine. A fabric resistant to F is described, and protective clothing is discussed. Burns due to F should be washed with copious amounts of water. $Mg(OH)_2$ paste and injections of 10% Ca gluconate are recommended as treatments. Corrosion and attack of materials by fluorine are discussed. Illustrative data on the reactivity of fluorine with a number of materials are tabulated. Materials showing resistance to F are Cu, Ni, Monel, Al, Mg, beta alumina (Na_2O. 11 Al_2O_3), and CaF_2 cement.

Apparatus and methods used in generation of fluorine are presented and problems indicated. Conveying at atmospheric pressure and higher pressures (above 5 lbs/sq. in. ga.) safely and efficiently is worked out with particular attention to valves, materials and instruments used. Compression to 30 or 40 lbs./sq. in. gage (using a diaphragm pump) is set as a safe limit. Storage can be accomplished safely, it is indicated, if proper precautions are taken. These are listed numerically. (cont'd on next page)

MDDC-154 Industrial Handling of Fluorine, by *R. Landau, R. Rosen.* 42 p. (See Also *Industrial and Engineering Chemistry*, Vol 39, P. 281-3, March 1947). (Cont'd from page 81).

Disposal is taken up with reference to the following methods: reaction with sodium chloride, reaction with caustic soda solutions, combustion, reaction with water, reaction with carbon, absorption by lime, and absorption by fluorides of lower valence state.

MDDC-155 Description of a Frequency Modulated Cyclotron and A Discussion of the Deflector Problem, by *E. J. Lofgren, B. Peters.* 4 p.

To verify the theory of the frequency modulated cyclotron (1) (2) which provides a means of overcoming the relativistic limitations of large cyclotrons a prototype was built using the 37 inch magnet. The variation of resonant frequency which will be caused by mass increase at large energies was here produced by a radial decrease in magnetic field.

At convenient values of modulation frequency (2000 c.p.s.) the energy gain per turn is so small that adjacent turns are only about 0.005 inches apart. Such spacing would seem to be insufficient to operate a conventional D. C. deflector since the exit strip would intercept most of the beam.

Precessional motion of orbits, however, can greatly increase the change of radius per turn. This was demonstrated by bombarding a probe in the circulating beam where activity was obtained as far as 0.2 inches back from the leading edge. This fact led authors to try a D. C. deflector, which successfully deflected up to 10% of the circulating beam of 8 MeV deuterons.

(1) V. Veksler, Journal of Physics U.S.S.R., 9, 153 (1945).

(2) E. MacMillan P.R. 68, 143, (1945).

MDDC-156 **Preparation of Fluorine**, by *K. E. Long, C. F. Swinehart, G. C. Whitaker.* 21 p.

Fluorine was required in large quantities, no large-scale production experience was available, and the estimated cost using existing laboratory and small pilot plant processes appeared excessive. A program of research was formulated, with the object of expediting large-scale production of fluorine by the investigation of the behavior of existing cells, and by the application of the knowledge gained to the design of improved cells.

In order to study the various factors affecting the production of fluorine, a number of small cells were constructed and modified as experimental work progressed. While early work had been done with round cells it was thought desirable to gain experience with rectangular cells, since this shape appeared to be more practical for large installations. Consequently, the experimental cells consisted of rectangular boxes, of welded steel construction, with removable covers supporting anodes, cathodes and diaphragm. The final design is presented in detail.

Significant findings are reported:

Nickel anodes containing 2.5% carbon were found to conduct current in electrolyte low in HF with very low nickel consumption.

A satisfactory method of making electrical contact between round carbon rods and buss bar inside the cell was developed.

Corrosion of the cell was reduced to a negligible amount by symmetrical arrangement of anode, diaphragm, and cathode.

Copper impregnated carbon anodes were found to be more satisfactory than plain carbon in the KF·2HF electrolyte containing lithium fluoride.

A partial thermal analysis of the system KF-HF-LiF was made.

Lithium fluoride, in addition to lowering the melting point of the KF.2HF to KF.HF electrolyte decreased the polarization of carbon anodes and practically eliminated polarization with copper-impregnated carbon anodes.

Large cells for the production of fluorine were designed which have operated continuously for two years.

MDDC-157 Frequency Modulation for Berkeley 37" Cyclotron, by *K. R. MacKenzie, F. H. Schmidt.* 10 p.

The system consists of a transmission line terminated at one end by the single cyclotron dee and at the other by a variable capacitor operating in a separate vacuum. A voltage node occurs near the center of the line.

15 kv dee voltage is produced by a grounded grid oscillator. The tubes are coupled to the dee stem by plate and filament coupling loops. Excitation phase is controlled by a capacitor in series with the filament loop. The voltage rises throughout the acceleration.

The vacuum capacitor consists of a steel disk 27" O.D. with 36 blades at its periphery rotating between a double set of stationary blades. The latter connect to the transmission line through a porcelain insulator. The disk is mounted on an insulator and forms one-half of a coupling capacitor to ground, thereby eliminating moving contacts.

The variable capacitor produces a modulation frequency up to 2,000 c.p.s. The frequency range is from 12 to 9.5 m.c. for deuterons and 24 to 18 m.c. for protons.

MDDC-158 Preparation of Polyhaloheptanes II. The Fluorination of Polychloroheptanes with Hydrogen Fluoride, by *E. T. McBee, et al.* 20 p.

Polychloroheptanes containing about 83% chlorine ($C_7H_4Cl_{12}$) were converted to polychloropolyfluoroheptenes containing about 29% chlorine and about 47% fluorine ($C_7H_xCl_3F_9$) by treatment with hydrogen fluoride and antimony (V) halides. The antimony residues can be recycled effectively in subsequent fluorinations if they are maintained anhydrous and are chlorinated prior to reuse. The effects of pressure, temperature and weight ratio of antimony (V) chloride to polychloroheptanes were studied.

MDDC-159 Preparation of Polyhaloheptanes III. Fluorination of Polychloroheptanes and Polychloropolyfluoroheptenes with Antimony (V) Fluoride, by *E. T. McBee, L. R. Evans, et al.* 13 p.

Polychloropolyfluoroheptenes containing about 55% chlorine and about 25% fluorine were converted to polychloropolyfluoroheptenes containing about 20% chlorine and about 55% fluorine by treatment with antimony (V) fluoride. The degree of fluorination depends primarily upon the mole ratio of antimony (V) fluoride to polychloropolyfluoroheptenes. Temperature and the method of introducing the reagents had no appreciable effect upon the degree of fluorination.

Polychloroheptanes containing about 83% chlorine was converted to polychloropolyfluoroheptenes containing about 20% chlorine and about 55% fluorine by treatment with antimony (V) fluoride.

MDDC-160 Preparation of Polyhaloheptanes IV. The Fluorination of Polychloropolyfluoroheptenes with Cobalt (III) Fluoride and Silver (II) Fluoride, by *E. T. McBee, et al.* 13 p. 10 fig.

Perfluoroheptanes, monochloroperfluoroheptane, and dichloroperfluoroheptane can be prepared from *n*-heptane in a three step process. Heptane is chlorinated photochemically to a mixture of polychloroheptanes containing an average of 12 chlorine atoms per molecule. The mixture is fluorinated with hydrogen fluoride and antimony (V) halides to obtain a mixture of polychloropolyfluoroheptanes containing an average of 9 fluorine atoms per molecule. This mixture is rectified to isolate the polyhaloheptenes containing less than 3 chlorine atoms per molecule for conversion to perhaloheptanes by fluorination with cobalt (III) fluoride or silver (II) fluoride. The chlorine content of the still residue is reduced by retreatment with hydrogen fluoride and antimony (V) halides.

The amount of chlorine replaced by fluorine with cobalt (III) fluoride or silver (II) fluoride is determined primarily by the temperature of the reaction. The ratio of perfluoroheptane to mono- and dichloroperfluoroheptane can be varied by variations in the composition of the polyhaloheptene fraction fluorinated. Under similar conditions, silver (II) fluoride is more effective for chlorine replacement than cobalt (III) fluoride. Perfluoroheptane prepared by this process is freed of chlorine containing contaminants by azeotropic distillation with methyl ethyl ketone.

MDDC-161 Preparation of Polyhaloheptanes V. Fluorination of Chloroperfluoroheptanes With Antimony (V) Fluoride, by *E. T. McBee, et al.* 8 p.

Chloroperfluoroheptanes were treated with antimony (V) fluoride for replacement of chlorine by fluorine. However, in no case was complete conversion of a mixture of chloroperfluoroheptanes to perfluoroheptane obtained.

MDDC-162 Preparation of Polyhaloheptanes VI. Identification and Reactions of Polyhalohydrocarbons and Halocarbons, by *E. T. McBee, et al.* 31 p.

Polyhaloheptenes having molecular formulas of $C_7H_2F_{12}$, $C_7H_2ClF_{11}$, $C_7H_2Cl_2F_{10}$, were isolated from the product obtained by the fluorination of polyhaloheptanes containing about 83% chlorine with hydrogen fluoride and antimony (V) chlorofluorides. These compounds were also obtained by the fluorination of a mixture having the average composition of $C_7H_xCl_6F_6$ with antimony (V) fluoride. These compounds were shown to be unsaturated by reaction with potassium permanganate dissolved in acetone and by addition of chlorine to the carbon-carbon multiple linkage.

Alkoxy derivatives were prepared by reaction of the polyhaloheptene fraction with sodium hydroxide dissolved in alcohol.

The polyhaloheptenes were converted to perhaloheptanes by fluorination with either cobalt (III) fluoride or silver (II) fluoride. In addition to C_7F_{16}, C_7ClF_{15} and $C_7Cl_2F_{14}$, compounds having average molecular formulas of C_7ClF_{13} and $C_7Cl_2F_{12}$ were isolated from the reaction mixtures.

Polyhalo and perhalo compounds containing from two to six carbon atoms were prepared. These compounds were believed to be contaminants in the polyhaloheptene and the perhaloheptane mixtures as a result of carbon-carbon cleavage.

MDDC-163 Preparation of Polyhaloxylenes I. The Preparation of Bis- (Trichloromethyl)Benzenes, by *E. T. McBee, et al.* 27 p.

This paper is limited to the chlorination of isomeric xylenes for the preparation of bis(trichloromethyl)benzenes. Initially, commercially available xylenes were chlorinated primarily for the preparation of mixtures of bis(trichlorometnyl) benzenes to be used as starting materials for the study on the preparation of bis(trifluoromethyl)benzenes. However, it soon became apparent that the nature of the starting material, i.e., the type of xylene used and the degree to which it was chlorinated, had an influence on the resulting yield of bis(trifluoromethyl)benzenes. Therefore, study was made of the relative rates of chlorination of *o*-, *m*-, and *p*-xylenes, 4-(chloromethyl)toluene, and special fractions of *m*- and *p*-xylenes. The maximum degree of chlorination and the main products of the chlorinations were determined for each type of xylene.

o-Xylene was chlorinated in 4 hours having an average composition corresponding to $C_8H_5Cl_5$; *m*-xylene was chlorinated in 8 hours to $C_8H_4Cl_6$; and *p*-xylene was chlorinated in 33 hours to $C_8H_3Cl_7$.

Xylene was chlorinated photochemically to a mixture analyzing $C_8H_3Cl_7$, a product with an average of at least one chlorine atom per molecule in the ring. Xylene was easily over-chlorinated to a mixture analyzing $C_8H_{2.5}Cl_{7.5}$. *p*-Xylene was over-chlorinated, but at a slower rate than *m*-xylene. The maximum degree of chlorination obtained was $C_8H_2Cl_8$. 4-(Chloromethyl)toluene did not over-chlorinate at the temperatures employed, but approached $C_8H_4Cl_6$ as the final product. Over-chlorination was due in part to chlorinolysis.

The degree of chlorination of technical mixtures of xylenes to obtain the maximum yield of bis(trifluoromethyl)benzenes depended on the ratio of the isomers, since the relative rates of chlorination of the isomers are different. Fluorination experiments supported this belief, showing that different fractions of technical xylenes necessitated different degrees of chlorination to obtain the maximum yields of bis(trifluoromethyl)benzenes.

MDDC-164 Preparation of Polyhaloxylenes II. The Preparation of Bis(Trifluoromethyl)Benzenes, by *E. T. McBee, et al.* 26 p.

The work discussed herein is limited to the preparation of bis(trifluoromethyl) benzenes by the fluorination of bis(trichloromethyl)benzenes with hydrogen fluoride. The investigation was conducted with 1,3- and 1,4- bis(trichloromethyl)benzenes and mixtures of these two, produced by the chlorination of *m*-xylene, *p*-xylene, and special fractions of commercial xylenes, respectively. The primary purpose of this research was to determine optimum conditions for the preparation of bis(trifluoromethyl)benzenes which were needed as intermediates in the preparation of perfluorodimethylcyclohexanes.

The effects of agitation, temperature, catalysts, and time on the fluorination of bis(trichloromethyl)benzenes, obtained by the chlorination of a commercially available xylene, with hydrogen fluoride were investigated. The conditions necessary to produce a high degree of fluorination, as determined from these studies, were applied to the fluorination of 1,3- and 1,4-bis(trichloromethyl) benzenes and mixtures of these two. Preparations of 1,2-, 1,3-, and 1,4-bis (trifluoromethyl)benzenes have been reported in the patent literature.

Satisfactory results were obtained by reacting bis(trichloromethyl)benzenes with hydrogen fluoride in an autoclave under autogenous pressure at 100°C in the presence of an antimony (V) chloride or antimony (III) fluoride catalyst, or at 150°C in the absence of a catalyst. There is little or no reaction unless agitation is employed, in which case the reaction is completed in 3 hours or less.

The best yield of bis(trifluoromethyl)benzenes (81%) was obtained by using 1,4-bis(trichloromethyl)benzene, although the less expensive mixture of chlorinated *m*- and *p*-xylenes gave reasonably good yields (44%). Yields of bis(trifluoromethyl)benzene from the chlorinated *m*-xylene, purified by distillation, were as high as 47%. As a result of over-chlorination of *m*-xylene the yield of usable fluorinated derivatives was increased to 60% by giving chloro-bis(trifluoromethyl)benzenes and increasing the yield of bis(trifluoromethyl)benzene.

Variations in the ratio of *m*-xylene to *p*-xylene require variations in the degree of chlorination in order to obtain the maximum yield of bis(trifluoromethyl) benzenes.

MDDC-165 Preparation of Polyhaloxylenes IV. Fluorination of Polychloro-Bis (Trichloromethyl)Benzenes, by *E. T. McBee, et al.* 20 p.

Mixtures of mono- and polychloro-bis(trichloromethyl)benzenes were converted to the corresponding chloro derivatives of bis(trifluoromethyl)benzenes by fluorination with hydrogen fluoride. Fluorination was successfully carried out in either of two ways; one was with hydrogen fluoride at super-atmospheric pressures and the other with hydrogen fluoride and antimony (V) chloride at atmospheric pressures. The products obtained by either method consisted primarily of monochloro-bis(trifluoromethyl)benzenes and dichloro-bis(trifluoromethyl)-benzenes. The ratio between the mono- and dichloro derivatives in the fluorination products depended upon the degree of chlorination of the starting material.

Fluorination of solid trichloro-bis(trichloromethyl)benzene with hydrogen fluoride at super-atmospheric pressures gave dichloromonofluoro-bis(trifluoromethyl)benzene as the only product isolated. This replacement of a chlorine atom attached to the aromatic nucleus by a fluorine atom was unexpected inasmuch as it is believed to be the first instance of such a replacement by means of hydrogen fluoride.

MDDC-166 Preparation of Polyhaloxylenes V. Addition of Chlorine to Dichloro-Bis(Trifluoromethyl)Benzenes, by *E. T. McBee, et al.* 13 p.

Mixtures of isomeric bis(trichloromethyl)benzenes were chlorinated readily in the presence of iron (III) chloride to mixtures of polychloroxylenes having an average composition corresponding to dichlorobis(trichloromethyl)benzenes. The most highly chlorinated xylene derivative obtained was trichloro-bis (trichloromethyl)benzene.

Mixtures of mono- and dichloro-bis(trichloromethyl)benzenes were converted to the corresponding chloro derivatives of bis(trifluoromethyl)-benzenes by fluorination with hydrogen fluoride. Fluorinations were successfully carried out either by reaction of the organic material with hydrogen fluoride at superatmospheric pressures or by reaction with hydrogen fluoride and antimony (V) chloride at atmospheric pressure. The product obtained, in either case, consisted primarily of monochloro-bis(trifluoromethyl)benzenes and dichloro-bis(trifluoromethyl)benzenes. The ratio between the mono and dichloro derivatives in the fluorination products depended upon the degree of chlorination of the starting material.

Fluorination of solid trichloro-bis(trichloromethyl)benzene with hydrogen fluoride at superatmospheric pressures gave dichloromonofluoro-bis (trifluoromethyl)benzene as the only product isolated. This replacement of a chlorine atom attached to the aromatic nucleus by a fluorine atom was unexpected in as much as it is believed to be the first instance of such a replacement by means of hydrogen fluoride.

MDDC-167 The Reaction of Polyhalogenated Aromatic Compounds with Antimony (V) Fluoride, by *E. T. McBee, et al.* 9 p.

This investigation was undertaken in order to establish a prototype for the action of antimony (V) fluoride on perhalogenated aromatic compounds containing aliphatic side chains. Antimony (V) fluoride was chosen as the fluorinating agent since it can be prepared without the use of fluorine, for at the time the investigation was undertaken the large scale production of fluorine appeared to be both expensive and difficult. It was desired that this reaction would effect both replacement of chlorine by fluorine and addition of fluorine to the double bonds, thereby resulting in the formation of oligochloropolyfluoronaphthenes having exceptional thermal and chemical stability.

Deeply colored complexes formed by the addition of antimony (V) fluoride to polyhalogenated aromatic compounds have been converted to a variety of products by the distillation of the reaction products from the reaction mixture and by decomposition of the complexes with dilute mineral acid. By suitable temperature control, pentachlorobenzotrifluoride was converted to pentachlorobenzoic acid, tetrachlorohydroquinone , tetrachloroquinone, trichlorononafluorocyclohexane, dichlorooctafluorocyclohexene, monochlorononafluorocyclohexene, and a mixture of polychloropolyfluorocyclohexanes; the yields were 95, 100, 100, 4, 54, 19, and 84%, respectively. The fluorinations of both polychloropolyfluoromethylbenzenes and ethylbenzenes were preceded by side-chain cleavage. An 87% conversion to dichlorooctafluorocyclohexene was obtained by the fluorination of hexachlorobenzene with antimony (V) fluoride.

MDDC-168 The Decompcsition and Analysis of Organic Fluorine-Containing Compounds, by *J. F. Miller, H. Hunt, E. T. McBee.* 1 p. (abstract only) (See Also *Analytical Chemistry*, Vol. 19 No. 3 P. 148-9, March 1947).

A method is presented for the decomposition and halogen analyses of organic fluorine-containing compounds. The decomposition is accomplished by reaction of the compound with sodium in liquid ammonia in a sealed system at room temperature. As a result of the decomposition, fluorine and other halogens in the molecule are converted to halide ions. The solution obtained after decomposition is suitable for use in the determinations without further separation. The determination of the fluoride ion is made by precipitation of lead chlorofluoride under closely controlled conditions of temperature and chloride ion concentration. The precipitate is dissolved and titrated. Other halogens are determined by standard methods. The method is applicable for halogen determinations in solid, liquid, and gaseous organic substances. Also, it is applicable to routine analysis of a large number of samples.

MDDC-169 Determination of Carbon in Halohydrocarbons Containing Fluorine, by *J. F. Miller, E. T. McBee.* 9 p.

A method was developed for the determination of carbon in halocarbons containing fluorine. The compound to be analyzed is burned with excess oxygen in the presence of a silica bearing material and copper oxide. The silicon tetrafluoride formed in the combustion is absorbed by passing it over hot aluminum oxide, the chlorine, if any, absorbed by passing it over metallic silver, the water, if any, absorbed by anhydrous magnesium perchlorate and, finally, the carbon dioxide absorbed in a tared, ascarite-filled absorption vessel. The gain in weight of the ascarite-filled vessel is a measure of the carbon dioxide formed in the combustion. The carbon content of the organic compound can be calculated from the weight of carbon dioxide formed. Attempts to determine hydrogen, simultaneously, by weighing the water, formed in the combustion and absorbed by the anhydrous magnesium perchlorate, were unsuccessful.

MDDC-170 Determination of Hydrogen in Fluorine-Containing Halohydrocarbons, by *J. F. Miller, H. B. Hass, H. Hunt, E. T. McBee.* 12 p. (See also *Analytical Chemistry*, Vol. 19, No. 3 p. 146-7, March 1947).

A rapid and accurate method is presented for the determination of hydrogen in fluorine-containing halohydrocarbons. The sample is pyrolyzed at 1300°C in a platinum tube in an atmosphere of nitrogen. Hydrogen fluoride and/or hydrogen chloride and chlorine are assumed to be the only products of thermal decomposition which are acidic in nature. The products of pyrolysis are swept from the platinum tube by a stream of nitrogen and are absorbed in distilled water. The resulting solution is filtered to remove carbonaceous material and aliquoted, if chlorine is present in the compound. Chlorine is determined in one aliquot by reaction with potassium iodide followed by titration of the released iodine with a sodium thiosulphate solution. Hydrogen peroxide is added to the other aliquot, the solution boiled for five minutes, and the total acidity determined by titration with standard alkali. A correction is made for the acidity due to free chlorine and the hydrogen concentration calculated from the net acidity. If fluorine is the only halogen present, the solution, after filtration, is heated to boiling, boiled and titrated without aliquoting and without the addition of hydrogen peroxide.

MDDC-171 Isotopic Absorption of Slow Neutrons in Cadmium, by *B. J. Moyer, B. Peters, F. H. Schmidt.* 8 p. (see also *Physical Review*, Vol. 69 No. 11-12, P. 666, June 1946).

Cadmium samples enriched in specific isotopes by a mass spectrograph are being studied with respect to thermal neutron absorption. [1]

A quick survey of the isotopic absorptions was made by comparing the slow neutron absorption of solutions of $CdSO_4$ made from the enriched samples with that of a normal $CdSO_4$ solution. A spherical bulb containing the solution under test was inserted in a neutron atmosphere produced by a Ra-Be source in paraffin. Supported at the center of the bulb were two indium detectors, one of which was cadmium shielded to measure the fast-neutron-produced activity.

Only the normal Cd and the Cd 113 solutions showed measurable absorption. The Cd 113 absorption equalled that of the normal solution when ratio of concentrations was 1 to 6.0 ± 0.4, respectively. It is concluded that the strong absorption in Cd is due to resonance capture in Cd 113.

Since the concentration of 113 in normal Cd is 1 part in 8, it appears that the sample enriched in 113 has a concentration of 70 - 80% in this isotope. Mass spectrograph analysis of the sample is to be made.

1. H. A. Bethe, *Review Modern Physics*, 9, 151, 1937.

MDDC-172 Development of a Commercial Cell for the Electrolytic Production of Fluorine, by *R. L. Murray, S. G. Osborne, K. E. Stuart.* 27 p.

A commercial size fluorine cell using carbon anodes was developed which, in ease of operation and renewal, is comparable to standard chlorine cells. No attempt was made to build a cell larger than 2000 amperes.

A considerable number of these cells were built and operated. In addition a larger number of existing cells originally designed for use with nickel anodes were modified to incorporate similar carbon anodes, and to conform to this design in many other respects, with definite improvement in economy and ease of operation.

Although the carbon anode cells themselves had reached a fairly satisfactory state of practical development and were operated in relatively large numbers in long series circuits, no adequate system for continuous HF feed was developed for use under these conditions; that is, on a scale such that the use of HF weighed out of cylinders became impractical.

Intermittent HF feed, batchwise, was found to be practical but did not give the best cell operation.

MDDC-173 Measurement of Electric Field Strength in a Cavity Resonant at 200 mc., by *W. K. H. Panofsky.* 4 p.

Two methods are described for measuring electric field strengths of the order of 25 kv/cm in a resonant cavity. The cavities are excited at frequencies in the neighborhood of 200 mc/sec by high-powered oscillators pulsed at a repetition rate of 15 p.p.s. with a pulse duration of 250 microseconds. One method consists of measuring the magnetic field inside the cavity by means of a loop method. The electric field is then computed by using the theoretical field distribution inside the cavity. The other method consists of measuring the electrostatic force produced on the diaphragm of a condenser microphone. This diaphragm is placed perpendicular to the direction of the electric field distribution. The diaphragm frequency response is adjusted to follow the build-up of field in the cavity faithfully. These techniques were developed to obtain design data for the construction of a linear accelerator.

MDDC-174 A Method for Measuring Small Changes in Alternating Magnetic Fields, by *W. M. Powell.* 4 p.

The magnetic field at the orbit of the electrons in a betatron or a synchrotron must sweep through zero at all points of the orbit at the same time. A small search coil with effective area 1300 cm^2 was placed in a 60-cycle magnetic field of 4000 oersteds. The voltage was integrated by an R-C circuit and the resulting signal was fed to the vertical plates of an oscilloscope. The horizontal sweep was fed by a sinusoidal voltage, which was phased so as to produce a diagonal line on the oscilloscope. A second search coil of slightly larger area connected in series with the first was placed in the field and rotated till the line became horizontal. The second coil bucked out most of the signal from the first coil. When the amplification of the vertical amplifier was increased, this line broadened out into an ellipse whose vertical minor axis gave a measure of the difference in the magnetic fields threading the two coils when the field is passing through zero. Variations of one-tenth of an oersted could be detected in this way.

MDDC-175 A Colorimetric Method for the Determination of Uranyl Ion, by *H. F. Priest, G. L. Priest*, 6 p.

In carrying out analyses for uranium in corrosion products by existing methods such as ignition to the oxide, silver reductor, or titration with ceric sulfate, it became apparent that a rapid, fairly accurate method for determining uranyl ion would be of great value.

The most logical color to use is that given by the ferrocyanide complex, but it proved to be unsatisfactory. Sodium salicylate also gives a color which has been used with some success, but its color appears to fade and is not very sensitive. A similar compound, sodium cresotate, was found to give stable orange-red color and is the reagent used. Method for preparing this reagent is described.

Procedure for an unknown sample: One-fifth of the amount of solution which is to be diluted in a 50 ml volumetric flask is placed in a test cell in the colorimeter and diluted to 5 ml. Reagent is added dropwise from a microburette until the maximum color is developed as evidenced by the colorimeter reading. Approximately five times this amount of reagent is thus necessary for the solution being prepared in the volumetric flask.

Precision of 2% or better can be obtained with this method.

MDDC-176 Measurement of Density of Liquid UF_6, by *H. F. Priest.* 3 p.

A tube was constructed, and after cleaning, the stem was calibrated with water at 27.5° and then with mercury at 27.5° using a thermostat and a precision cathetometer. The bottom of the tube was chosen as the reference point. The two methods of calibrating gave points all falling on the same line. The total volume up to the place marked "seal off point" was determined using water. The total weight of the tube and ground joint was determined and it was then fastened to a vacuum system by means of the joint using "Apiezon W" over the top of the joint as a seal. It was outgased at 10^{-5} mm Hg for two days with frequent flaming and then 5.5919 grams of resublimed UF_6 was sublimed into the tube. It was sealed off at the seal off point and weighed. The ground joint was removed and weighed after cleaning. This gives an accurate weight of UF_6 by a difference method. The bulb was then completely immersed in a bath at 65.1°C measured with a B.S. thermometer. The height of the column of liquid was measured with a cathetometer and turned out to be 10.875 cm. This brought the meniscus just into the divergent portion of the stem. A correction was made for this by measuring the conical section thus introduced, and this turned out to be .030 $cm.^3$ The volume of the liquid was 1.491 $cm.^3$ The volume of saturated vapor was 6.364 cm^3 which then corrected to standard conditions is 7.780 $cm.^3$ This corresponds to 0.1222 grams of UF_6 leaving 5.4697 grams as liquid. The density then turns out to be 3.667 grams /cm^3 ± 0.05 gr/cm^3.

MDDC-177 Preparation of Uranium Pentafluoride, by *H. F. Priest.* 7 p.

The reaction was carried out in a copper reactor, which held 100 grams of uranium tetrafluoride in a removable tray. The reactor was fitted with valves and a bolted flange cover for easy removal of the product. The tray was filled with uranium tetrafluoride, placed in the reactor and the cover bolted in place, using an aluminum gasket. It was heated to 250°C in a stream of fluorine until there was a strong evolution of hexafluoride. The valves were then shut, and the reactor allowed to cool. When at room temperature, the reactor was evacuated using a cold trap until no more hexafluoride could be removed. The valve was closed and the reactor placed in a dry box, which was then thoroughly flushed with dry nitrogen. When the atmosphere in the box was dry, the reactor valve was opened to admit dry nitrogen to the reactor, and the reactor cover was removed. The material was transferred to a glass tube with a tight cap and placed in a desiccator. On some preparations the pumping off of the excess hexafluoride was done after transfer to glass. The uranium pentafluoride reacts very rapidly with moist air and can be handled only in a good dry box. It is light gray in color and appears to be isomorphous with uranium tetrafluoride.

MDDC-178 Report on the Storage of Fluorine Under Pressure, by *H. F. Priest.* 3 p.

Two cylinders were made of copper tubing 18" long with spherical heads and fitted with a Korotest diaphragm packing valve having an inner copper diaphragm and a copper seat. The fluorine generator was run for two hours and the fluorine condensed directly in a copper trap.

This copper trap was then connected to the fluorine cylinder and the liquid fluorine allowed to evaporate, after which the cylinder valve was closed and the trap removed. The calculated pressure in the cylinder was 200 lbs/sq. in., but no gauge was included to determine the actual pressure.

Apparently this method of storing fluorine is very satisfactory and it should be possible to store it in either copper or nickel cylinders for low pressures or steel cylinders lined with either of these two metals for high pressures.

MDDC-179 The Thermal Conductivity of Liquid UF_6, by *H. F. Priest.* 11 p.

The value for the thermal conductivity of liquid UF_6 at 72°C. was found to be 3.83×10^{-4} $\frac{\text{cal. cm}}{(^\circ\text{C})\ (\text{sec.})\ (\text{cm}^2)}$.

This is a value averaged over the temperature range from the cold plate temperature to the hot plate temperature. 72°C. is the midpoint of this temperature range for these runs. The temperature coefficient of the thermal conductivity of a liquid is usually quite low and no attempt was made to measure it here.

MDDC-180 Use of a Hydrogen-Fluorine Torch to Weld Copper, by *H. F. Priest*. 2p.

A hydrogen-fluorine torch has been constructed using concentric copper tubes at the tip. The inside tube through which the fluorine passes is .042" I.D. copper and the outer tube which forms an annular space for the hydrogen to pass is .072" I.D.

The flame produced is very hot and melts copper without oxidation. Two pieces of 1/16" thick copper plate were scarfed and welded, using the torch described above. 1/16" copper wire was used to supply metal to the weld. The copper flowed very well, being somewhat like brazing spelter in its action. When cooled, the weld looked very much like a weld in steel and a cross section showed only pure copper in the weld with no inclusions.

The hydrogen fluorine torch welds copper as easily as oxyacetylene welds steel and gives a weld with no inclusions.

MDDC-181 The Vapor Pressure of Uranium Hexafluoride In Equilibrium with Uranium Pentafluoride, by *H. F. Priest*. 7 p.

The pressure was measured with a sylphon bellows type null point gauge which had a 3-meter optical lever so that 2 cm. on the scale corresponded to 0.1 mm. pressure. The UF_5 was put in a platinum thimble which was placed in the glass tube fitted with a standard taper joint. This joint was put together dry and sealed on the outside with picein, a procedure previously used with UF_6. A glass thermocouple well extended down into the platinum thimble, and a calibrated copper-constantan thermocouple, the cold junction of which was in an ice bath, was used for measuring the temperature in the platinum thimble. The glass tube containing the platinum thimble was connected to the pressure device, and a side arm fitted with a nickel valve was used to connect the whole to vacuum system.

The pressure was read on a manometer with an invar scale, using a mirror reading device to obviate reading errors. Each point was checked several times with the UF_6 being pumped out between runs.

In each run a small side arm on the system was cooled in liquid air and sealed off. The material obtained was checked qualitatively, and in each case was definitely UF_6. Freezing down in this fashion always dropped the pressure to 0.00 mm indicating that there were no noncondensible gases.

Two runs were made and averaged. The actual data are shown in Table I.

(cont'd on next page)

MDDC-181 The Vapor Pressure of Uranium Hexafluoride in Equilibrium with Uranium Pentafluoride, by *H. F. Priest.* 7 p. (Cont'd from page 97).

TABLE I

Temp. °C.	P mm Run I	P mm Run II	Average
128.5	1.6	2.0	1.8
165.2	11.2	11.2	11.2
192.5	31.8	31.8	31.8
197.0	37.1	37.3	37.2
215.3	65.95	65.65	65.8

MDDC-182 The Nuclear Reaction (p,pn), by *J. R. Richardson, B. T. Wright.* 3 p.

The 16-Mev protons produced by the 37-inch FM cyclotron have been used to bombard several elements. Evidence for the occurrence of the new reaction (p,pn) has been obtained in the cases of copper and antimony. In particular the 12.8-hour period in copper has been obtained, presumably from the reaction Cu^{65} (p,pn) Cu^{64} and the 16-minute period in antimony, presumably from the reaction Sb^{121} (p,pn) Sb^{120}. The usual precautions against neutron activation have been observed. A preliminary excitation curve has been obtained in the case of copper. It is a steeply rising curve, with a threshold at about 13-Mev proton energy.

MDDC-183 **Boron Trifluoride Neutron Detector for Low Neutron Intensities, by** *E. Segre, C. Wiegand.* **14 p. (See also *Review of Scientific Instruments*, Vol. 18, No. 2 P. 86-89 Feb. 1947).**

A sensitive boron trifluoride ionization chamber for the detection of weak neutron sources is described. Its efficiency for Ra-Be neutrons is about 2 percent with a background of 15 c/min.

MDDC-184 Segre Isotope Chart, by *E. Segre.* 1 chart

Note: This chart has been revised and reissued as MDDC 626.

MDDC-185 Thick-Target Excitation Functions for Alpha Particles, by *E. Segre, C. Wiegand.* 6 p.

The integral excitation functions of the (α, n) reaction for full energy (5.30 Mev) polonium alphas on Be, B, F, have been measured. The yields (neutrons per million alphas absorbed in the element) are:

Be	B	F
73	19	10

For alpha particles of U^{234} assuming that they have a range of 3.21 cm (4.70 Mev) the yield would be (neutrons per million alphas)

Be	B	F
55	14	6

MDDC-186 The Reaction of Fluorine Oxide with Sodium Hydroxide, by *E. Simons, T. P. Wilson, S. C. Schuman,* 4 p.

The reaction of fluorine with gaseous or liquid water and with caustic is not completely understood. Oxygen, ozone, fluorine oxide, peroxide, and hypofluorites have been postulated as reaction products. It is certain that the molecular mechanism of fluorine hydrolysis is not simple and is altered by phase, pH, temperature, reaction contact time and specific reaction surface.

For the determination of F_2O, a conventional Orsat apparatus was employed using KI as absorbent. To further substantiate this method of analysis, the I_2 formed on absorption was titrated with standard thiosulfate.

Results are tabulated. The weight percent F_2O is the mean of results obtained gasometrically and by titration. The weight percent F_2O left represents the percent F_2O at time t divided by that at zero time. For each concentration of NaOH and temperature, results are expressible in accordance with the rate equation for a first order reaction. The value of the specific rate constant (k) may be calculated to be:

10% NaOH at 22°C; $k = 0.34$ min.$^{-1}$
1% NaOH at 60°C; $k = 0.10$
1% NaOH at 21°C; $k = 0.045$

The rate of reaction increased sharply upon agitation of the mixture of reactants. Some of the results are: (Cont'd on next page)

MDDC-186 The Reaction of Fluorine Oxide with Sodium Hydroxide, by *E. Simons, T. P. Wilson, S. C. Schuman.* 4 p. (Cont'd from page 100).

Reaction of F_2O With NaOH

T°C	P mm. Hg.	NaOH Wt. Percent	Time, Minutes	% F_2O in Gas	% F_2O Left	Notes
21	760	1	0	33.2	100.0	
			6.5	25.1	75.7	
			40.0	4.0	12.0	
59	760	1	0	31.2	100.0	
			5.5	17.2	55.2	
			30.0	1.0	3.2	
29	761	10	0	36.0	100.0	
			2.0	17.7	49.2	
			5.0	6.9	19.1	
29	757	1	0	38.7	100.0	
			2.0	8.4	21.8	
			5.0	2.5	6.3	
28	758	10	0	36.7	100.0	Reaction Agitated
			2.0	5.9	16.1	
			4.0	0.9	2.3	
21	760	0.7	0	9.0	100	
			10.0	6.3	70	
			44.0	1.0	11	

MDDC-187 Acceleration of Stripped Light Nuclei in the Cyclotron, by *H. York, R. Hildebrand, T. Putnam, J. G. Hamilton*, 4 p.

Experiments have been done to produce accelerated stripped light nuclei with the 60" Berkeley cyclotron for use in nuclear experiments. Two types of sources have been investigated; an arc source such as that normally used in cyclotrons and a spark source similar to that used in spectroscopic investigations of highly ionized atoms. Typical yields from an arc source are 10^3 $C^{13,+6}$ 146 Mev. ions per second and 10^5 $C^{12,+6}$ 135 Mev. ions per second. Experiments with C^{+6} have previously been done at lower energies with the 37" Cyclotron by L. W. Alvarez,[1] and with the 60" cyclotron by Tobias and Segre,[2] and Condit,[3] who also reported O^{+8}.

1. Alvarez, *Phys. Rev.* 58, 192 (1940)
2. Tobias, Ph.D. Thesis, Univ. of Calif. 1941
3. Condit, *Phys. Rev.* 69, 301 (1942)

MDDC-188 Spherical Proportional Counter, by *H. Agnew*, 10 p.

A spherical proportional counter is described which records recoils and shows no asymmetry in detecting a neutron beam incident from different directions. The central electrode consists of two circular loops of fine wire.

MDDC-189 Boron Cross-Section for Neutrons from 0.01 to 1000 ev, by *E. E. Anderson, L. S. Lavatelli, B. D. McDaniel, R. B. Sutton*, 21 p. (See also *Physical Review* Vol. 71, No. 4, P.272, Feb. 15, 1947).

The time of flight method has been used to measure the transmission of boron absorbers for neutrons in the energy range from 0.01 to 1000 ev. The cross sections corresponding to the observed transmissions have been computed. The results indicate that the absorption cross section σ_a follows the 1/v law to within ten percent in this region. Extrapolation of the total cross section to infinite energy yields the value of 4.2 ± 0.4 barns for the scattering cross section. The value of $\sigma_a v$ was found to be 1.61 ± 0.02 barn m/μsec.

MDDC-190 The Preparation of Sodium Trifluoroacetate and Ethyl Trifluoroacetate, by *J. H. Babcock, C. I. Gochenour, A. D. Kischitz*, 9 p.

Hexachlorobutadiene is prepared by chlorinating n-butane to hexachlorobutane, followed by the chlorinolysis (Cl_2 at 475°C) of the hexachlorobutane mixture. The hexachlorobutadiene is then fluorinated and the resulting fluorochlorobutenes oxidized by alkaline permanganate to sodium trifluoroacetate. Ethyl trifluoroacetate is prepared in 90% yields by allowing the sodium trifluoroacetate to react with alcohol and sulfuric acid.

MDDC-191 Research Program - Biology and Medicine, by *A. N. Brues.* 6 p.

This report discusses in very general terms the uses of biology in nucleonics from the standpoint of radiation protection, tolerance levels, diagnosis, treatment and military aspects. The use of nucleonics in biology is also discussed in the application of tracers, effects of radiation, and new tools for radiation therapy.

MDDC-192 Some Remarks on the Hydrodynamical Theory of Wave Propagation with an Application to a Problem in the Flow of Metals Incompressible at Low Pressure, by *J. W. Calkin.* 8 p.

The behavior of a fluid at a surface S of discontinuity of higher order (i.e., not a Shock) are discussed without reference to the equation of state. In particular, the formulae

$$\rho v_x \Delta\left(\frac{\delta n_{vx}}{\delta x^n}\right) = -\Delta\left(\frac{\delta n_p}{\delta x^n}\right)$$

$$\Delta\left(\frac{\delta n_{(ov_x)}}{\delta x^n}\right) = 0,$$

$$\Delta\left(\frac{\delta n_p}{\delta x^n}\right) = c^2 \Delta\left(\frac{\delta n_o}{\delta x^n}\right)$$

for a discontinuity of order n, $n \geq 1$ are established, where x is the direction normal to the surface, p is pressure, ρ density, V_x velocity in the x-direction, c the velocity of propagation of S, and Δ the discontinuity of the indicated function. If $dp/d\rho$ exists the third formula yields the theorem of Hadamard that such surfaces propagate with sound-velocity (if there is material flow across them). The third formula is also applied to show that a surface forming the boundary between a metal in an incompressible phase where $p < p_o$, $\rho = \rho_o$ and in a phase where $p = p_o$, $\rho > \rho_o$, must be a discontinuity of order greater than 1, and at the same time gives the velocity of propagation of such boundary.

MTDC-193 Preparation and Properties of Sulfides and Oxide-Sulfides of Uranium, by *E. D. Eastman, et al*, 8 p.

The results of a study of three methods of preparation and properties of US, U_2S_3, US_2, and UOS are summarized.

MTDC-194 Process Monitor, Mark 10, Model 20, by *W. P. Jesse*, 2 p.

This instrument is used with a Geiger-Mueller tube to monitor the intensity of gamma radiation. An alarm rings at a predetermined counting rate. Circuit diagram included.

MDDC-195 **The Complete Analysis of Fluorine Gas, by *R. H. Kimball, L. E. Tufts,* 28 p.**

A method is described for either the precision or the routine analysis of fluorine gas. The sample is passed through a tube of granular NaF, in which HF is absorbed and determined. It then passes over dry NaCl, which converts it to chlorine. For routine control the chlorine is sampled in a bulb and analyzed for oxygen and inerts. For complete analysis of minor constituents, a large sample is absorbed in a strong solution of potassium hydroxide and potassium arsenite. Chlorine and carbon dioxide are determined by analysis of this solution. The residual gas is analyzed in an Orsat apparatus. The method is equally applicable to the analysis of chlorine from any other source.

MDDC-196 **The Determination of Fluorine and Chlorine in Organic Compounds, by *R. H. Kimball, L. E. Tufts,* 20 p. (See also *Analytical Chemistry,* Vol. 19, No. 3, P. 150-153, March 1947).**

A method for the analysis of organic compounds containing fluorine, or both fluorine and chlorine is described. The sample is weighed in a gelatin capsule or glass ampoule, and heated with metallic potassium in a nickel bomb at 500-550°C for two hours. The bomb is washed out and the resulting solution is made up to volume. Half of this solution is titrated for chloride by the Volhard method. The other half (or less) is analyzed for fluoride by distillation and titration with thorium nitrate.

The method is particularly suitable where high accuracy is desired. The bomb method of decomposition is very convenient and certain, and the determination of chloride is short and simple. The distillation and titration of fluoride are rather laborious, and correct interpretation of the end point requires some practice. It is probable that the lead chlorofluoride method as recently improved by Donovan could be used in the determination of fluoride, with some saving in the time required of the analyst.

MDDC-197 **A Mass Spectrometer for Routine Hydrogen Isotope Analyses, by** *A. O. C. Nier, M. G. Inghram, G. Stevens, B. Rustad*, **31 p.**

Description is given of a compact mass spectrometer which can be operated entirely from alternating current if desired, uses small Alnico magnets to supply the magnetic field, collects ions of mass two and mass three simultaneously on separate collectors, and the mass 3 ion/mass 2 ion ratio can be read directly on a decade divider. Circuit diagrams and parts lists are included.

MDDC-198 **A Null Method for the Comparison of Two Ion Currents in a Mass Spectrometer, by** *A. O. Nier, E. P. Ney, M. G. Inghram*, **7 p. (See also** *The Review of Scientific Instruments*, **Vol. 18, No. 5 P. 294-297 May 1947).**

A method of determining the ratio of two small currents which vary intermittently or continuously, but always have the same relative magnitudes, is described. Although applied only to the case of making precise measurement of ratio of two ion currents in a mass spectrometer for the purpose of measuring the relative abundance of isotopes, the method would be useful in other applications as well.

MDDC-199 **Fluorine and Fluorocarbon Chemistry, by *G. W. Russell*, 1 p.**

1. Elemental fluorine may be generated electrolytically by the electrolysis of HF from an electrolyte with a composition KF·1.8HF plus 1% LiF. The cell is a jacketed steel tank with copper impregnated carbon anodes, a steel screen diaphragm and a steel cathode skirt. The cell is operated at a temperature of 100°C ± 5°C with a cathode voltage of minus 2, an anode voltage of 6, and a current density of approximately 50 amperes per square foot of anode surface.

2. Elemental fluorine may be compressed by several methods, two of which are:

   (a) By liquefaction of fluorine with liquid nitrogen or oxygen followed by heating and expansion of the fluorine into a lower pressure container.
   (b) By use of an ordinary gas compressor either oilless, or lubricated with a completely fluorinated oil.

3. Elemental fluorine may be introduced into an organic molecule with only minor attack on the carbon linkage in either gas phase, or in liquid phase in an inert completely fluorinated solvent. A cyclic process utilizing the multi-valent properties of silver, cobalt, manganese, or cerium as the fluoride "catalyst" or "carrier" is used. First the lower valent metal fluoride is raised to the higher valence with elemental fluorine. After purging the system with an inert gas such as nitrogen, the organic material to be fluorinated is brought in contact with the metal fluoride at an elevated temperature which releases fluorine to the organic compound replacing hydrogen or chlorine. After the higher valent metal fluoride has been exhausted of active fluorine, the system is purged again with an inert gas and the metal fluoride is reactivated with elemental fluorine.
   For example:

   (a) Activate the lower valent metal fluoride
   $$12CoF_2 + 6F_2 \longrightarrow 12CoF_3$$

   (b) Fluorinate the organic material
   $$12CoF_3 + C_2H_6 \longrightarrow C_2F_6 + 6HF + 12CoF_2$$

   (c) Reactivate the lower valent metal fluoride
   $$12CoF_2 + 6F_2 \longrightarrow 12CoF_3$$

MDDC-200 Orbits of Particles in the Racetrack, by *R. Serber*, 3 p. (See also *Physical Review*, Vol. 70 Nos. 5-6, P. 434-435, Sept. 1946).

In the racetrack the electrons move in two semicircular magnetic fields, connected by straight field-free legs. An electron moving in the magnetic field will, if displaced from the equilibrium orbit experience focussing forces tending to bring it back to this orbit. For a circular magnetic field whose radial dependence is $1/r^n$, the resulting motion is harmonic oscillation about the equilibrium orbit with frequency $n^{\frac{1}{2}}w$ for the vertical motion, $(1 - n)^{\frac{1}{2}}w$ for the radial motion. Here w is the frequency of revolution of the electron. However, the straight section introduces an element of instability, since an electron entering it at an angle will suffer a diaplacement proportional to the length of the straight section. If the straight section is made sufficiently long the magnetic focussing forces will no longer be able to overbalance this displacement. Thus, if L is the length of the straight sections and d is the diameter of the equilibrium circle in the magnetic field, there will be a limiting value of L/d beyond which the orbits become unstable. For n values $n = 0.56$ and $n = 0.75$ corresponding limits are $L/d < 0.56$, and $L/d < 0.25$. Other limitations of the race track are discussed.

MDDC-201 Distribution of Neutrons in the Atmosphere, by *H. M. Agnew, W.C. Bright, D. K. Froman*, 4 p. (See also *Physical Review*, Vol. 72, No. 3. P. 203-206 Aug. 1, 1947).

A B-29 airplane has been used to carry counters filled with BF_3 enriched in B^{10} to an altitude of 30,000 feet above sea level. Experiments in progress will be extended to 45,000 feet. The tail compartment contained a bare counter, one completely covered with 0.030" Cd, and one covered with 2.54 cm of B_4C. All hydrogenous material within 25 feet of these counters was removed. The radar room contained a counter completely covered with a 5 cm of paraffin surrounded by a layer of 0.030" Cd. The counting rate in all counters varied in same way with altitude in the pressure range from 20 to 50 cm Hg. Within this pressure range the intensity I is given quite accurately by the relation $I = I_o e^{-0.083\rho}$ where P is the pressure in cm of Hg at altitudes above 7000 feet. A constant Cd ratio of 2.2 was obtained. The data above are uncorrected for counts not caused by neutrons. The high biases used should make the corrections small, and the corrections will be determined by using counters filled with normal BF_3. A definite cloud effect has been noted and further investigation is planned. Repeat counts taken during flight show that the amount of gasoline carried by the plane does not affect the counting rates.

MDDC-202 **Preparation of N-Polychloropolyfluoroheptene, by** *J. H. Babcock, W. S. Beanblossom, B. H. Wojcik*, 38 p. (See also *Industrial and Engineering Chemistry*, Vol. 39 No. 3 P. 314-319 March 1947.

A method applicable to the commercial production of a highly fluorinated polychloropolyfluoroheptane was developed through the pilot plants. This consisted of the following steps·

1. Chlorination of n-heptane to 82 - 83% Cl_2 which corresponds to dodecachloroheptane.

2. Hydrofluorination of this material with anhydrous HF and $SbCl_5$. The $SbCl_5$ appeared to be more than just a catalyst since the reaction was very slow when only catalytic amounts were used and it was found desirable to use an amount of $SbCl_5$ equal in weight to the chloroheptane to be fluorinated. However, this could be reused, it being only necessary to add approximately 10 per cent of fresh material with each run to replace mechanical losses.

3. Fractional distillation to remove the highly fluorinated material and recycling of the less completely reacted material.

During these reactions, some dehydrohalogenation took place so that the final product had an average composition of $C_7H_2F_{10.5}Cl_{1.5}$ which could be converted to a satisfactory product by treatment with either cobalt trifluoride or silver difluoride.

MDDC-203 Comparison of X and B Radiation Effects in Rabbits, by *F. W. Bishop*, 12 p.

The minimal dosage necessary to produce an erythematous reaction in the ear of the rabbit with 30 KV x-rays is in the neighborhood of 1,000 r. A somewhat smaller dose (900 r) was able to cause epilation without erythema. Generally the phenomenon of epilation either appears at a lower dosage level or a higher percentage of the animals are epilated than show erythema for a given dosage. As might be expected, the erythema appears sooner and generally lasts longer at the higher dosage levels and epilation also occurs earlier under these circumstances. Scaliness of the areas treated was a usual accompaniment of the erythema but its appearance time and duration was erratic.

The lowest dose of beta rays capable of causing an erythema in the rabbit's ear is near the level of 3,000 rep. Epilatic was not observed until a dose of 3,500 rep had been administered and the p rcentage epilated was less for a particular dose than that developing erythema. Generally the appearance time of the epilation was considerably longer than that of the erythema. Scaliness without any other sequela was noted at low dosage levels but was as variable as in the case of the x-rayed rabbits.

These few experiments indicate that from three to five times the dosage is necessary in the case of beta rays to produce a given effect; e.g., it required approximately three times the dose of beta rays as compared with low voltage x-rays to produce a minimal erythema, about four times the dose to cause the first signs of epilation and about 4½ times the dose to produce epilation in all the animals treated.

MDDC-204 Observations on Populations of Animals Exposed to Chronic Roentgen Radiation, by *R. D. Boche*. 56 p.

This report discusses the effects of chronic roentgen radiation on the basis of survival of animals, and the effects on their reproductive systems. Dogs, rabbits, mice, rats and monkeys were used as the experimental animals in this study.

MDDC-205 Angular Distribution of n-d Scattering for 2.5-Mev Neutrons, by *J. H. Coon, H. H. Barschall*, 17 p. (See also *Physical Review*, Vol. 70 Nos. 9-10, P. 592-596, Nov. 1946).

The angular distribution of the scattering by deuterium of 2.5 Mev neutrons was measured by analyzing the distribution in energy of the recoiling deuterons in an ionization chamber. In the center of mass system the differential cross section exhibits a maximum is more than twice the value at angles near 90°. Neutron-proton scattering observed under similarconditions showed a departure of not more than 10 percent from isotropic scattering.

MDDC-206 Measurement of the Cross Section for the Reaction d (d,n) He^3, by *J. H. Coon, et al*, 12 p.

The total neutron yield from a thick, heavy-ice target was measured at four bombarding energies from 100 to 300 KV by comparison of the activity induced in a large tank of $MnSO_4$ solution surrounding the source. Cross section values are given based on the latest energy-loss estimates for deuterons in D_2O.

Neutron energy (Kev)	Thick target yield neutrons/deuteron	Cross section (10^{-26} cm^2)
119	1.10×10^{-7}	2.47
171	2.26×10^{-7}	3.68
220	3.60×10^{-7}	5.13
294	7.07×10^{-7}	8.35

MDDC-207 Measurement of the Cross-Section for the Reaction d (d,p) H^3, by *J. H. Coon, et al*, 6 p.

The total proton yield from a thick, heavy-ice target has been measured for four bombarding voltages between 100 and 300 KV by counting protons emerging from the target chamber at three angles. Cross-sections are given based on the latest energy-loss estimates for deuterons in D_2O.

Neutron energy (Kev)	Thick target yield protons/deuterons $\times 10^7$	Cross section (10^{-26} cm^2)
122	0.78	2.63
171	1.74	3.26
219	2.96	3.90
300	5.48	5.16

MDDC-208 **Precautions to be Observed in Handling, Shipping, and Storage of Fluorine, by *District Safety Branch*, 7 p.**

Precautions to be used in handling fluorine are given. Included also are the physical properties of fluorine, the physiological effects of contact with human flesh, protective equipment to be used in handling the gas, shipment and storage regulations and emergency first aid treatment that should be given upon exposure.

MDDC-209 **The Preparation of Chlorofluorocarbons, by *R. C. Downing*, 41 p. (See also papers published in *Industrial and Engineering Chemistry*, Vol. 39, No. 3, P. 346-354 March 1947).**

The preparation of monochlorofluoroheptane from polychloroheptane was studied for the purpose of obtaining process data, particularly on the final treatment with cobalt trifluoride. Some perfluoroheptane was also formed, especially at higher temperatures and lower feed rates.

The replacement of chlorine by fluorine in condensation products obtained from unsaturated chlorocarbons was explored and a variety of products was obtained. It was not possible to entirely remove the chlorine with the common fluorinating agents.

Various other chlorofluorocarbons were prepared from aromatic and alicyclic compounds and from long carbon chain aliphatic oils and waxes. Some of the products indicated suitable physical characteristics in preliminary tests but none of them was studied extensively.

MDDC-210 Neutron Spectroscopy, by *J. R. Dunning*, 31 p.

A general outline of the progress made in neutron spectroscopy and some speculation as to its future possibilities are briefly discussed under the following headings. Mechanical Velocity Selector, Boron Absorption Methods, High Voltage Generator - Controlled Neutron Energy, Crystal Spectrometer, Modulated Cyclotron Velocity Selector, Neutron Energy Distribution from Paraffin, Boron 1/v law, Neutron Proton Interaction, and Neutron Crystal Diffraction Phenomena.

MDDC-211 Blood Chemistry Study in Dogs Exposed to Chronic X-Radiation, by *K. Fink*, 16 p.

The purpose of this study was to determine whether some of the biochemical components of the blood were affected in dogs by chronic x-radiation at 0.1r, 0.5r, 1.0r, and 10r per day over a long period of time.

The concentrations of serum protein, plasma fibrinogen, whole blood NPN, serum cholesterol, serum chloride, and serum acid and alkaline phosphatases were not significantly altered in dogs subjected to chronic x-radiation at 0.1r, 0.5r, 1.0r and 10r per day, six days a week. All the dogs in the 10r groups and four dogs in the remaining groups succumbed before the experiment was terminated at the time of 622 exposures. There were no consistent changes even in the dogs which died as a result of the radiation. The only obvious changes observed in the dogs given 10r per day which died were high fibrinogen concentrations in three of the dogs, two of which had high alkaline phosphatase levels. These changes did not develop until about a week before the animals died, so even had they occurred in all the dogs which died, they would have been of little practical value as an index to radiation damage.

MDDC-212 Callicrein and Radiation, by *K. Fink*, 34 p.

Similarities in the reaction of dogs to radiation and to callicrein suggested the possibility that callicrein may be involved in some way in the biological effects of radiation. Experiments were therefore undertaken to investigate callicrein as a possible agent responsible for some of the biological changes occurring after roentgen radiation.

The experimental work described is insufficient to determine whether callicrein is a prominent factor in the production of the biological changes which occur after irradiation. Even if the indirect evidence that the output of callicrein in the urine is decreased following irradiation is correct the present knowledge of callicrein is too inadequate to interpret the finding.

MDDC-213 The Vapor Pressures and Critical Constants of C_4F_{10}, C_7F_{16}, C_7F_{14} and C_8F_{16}, by *R. D. Fowler, et al.*, 21 p.

Vapor pressure data are given for C_4F_{10}, C_7F_{14}, C_7F_{16} and C_8F_{16}, over a general temperature range of 0°C to 100°C. The static vapor pressure of the low boiling C_4F_{10} was measured in a metal system with Bourdon-tube gauges, while the higher boiling compounds were studied using an isoteniscope. The heats and entropies of vaporization were calculated from the data, and appear normal for relatively non-associated liquids.

The critical temperatures of C_4F_{10}, C_7F_{14}, and C_7F_{16}, and the orthobaric liquid and vapor densities of C_4F_{10} were determined. The critical density of the latter was extrapolated from the orthobaric densities, using the Law of Rectilinear Diameter. Critical pressures, based on the heats of vaporization, have been included.

MDDC-214 Synthesis of Fluorocarbons by the CoF_3 Process, by *J. M. Hamilton, Jr.* 67 p.

A practical and general synthesis for completely fluorinated organic compounds has been developed, consisting essentially of reaction between cobalt trifluoride and vaporized hydrocarbons or fluoro-hydrocarbons at elevated temperatures. A number of pure perfluorocarbons, ranging from ϕ-n-butane to ϕ-cetane, have been produced and characterized. In addition, certain reaction by-products have been identified.

Pure ϕ-n-heptane has been obtained in yields up to 78% from n-heptane and pure ϕ-dimethyl cyclohexane in 88% yields from hexafluoroxylene. Crude yields for these two feed stocks were 91% and 97% respectively, and even with high boiling feed stocks such as light lubricating oils yields of fully fluorinated material in excess of 50% were obtained.

The variables of the reaction have been studied, and improved equipment designed on the basis of the results. These variables included reaction temperature, dilution of the hydrocarbon with inert gas, contact time, degree of CoF_3 exhaustion, and changes in feed stock. In addition, a rough measurement has been made of the heat of the reaction between F_2 and CoF_2, and the result used to calculate the heat of the reaction between the resulting CoF_3 and hydrocarbons.

MDDC-215 The Effect of Acute and Chronic Doses of Roentgen Rays on Monkey Finger Ridge Detail, by *R. A. Harvey*, 16 p.

Within the time limits of these experiments:

1. Acute roentgen exposures up to 800 r cause no detectable gross changes in finger ridge details of monkeys. Acute doses of 800 r to 1,100 r result in temporary atrophy of ridges. Acute doses above this level cause more severe atrophy, slower regeneration, less complete regeneration and some tendency to secondary weakening of detail.

2. Chronic roentgen exposures of 10 r per day for 50 treatments cause no change in ridge detail. Chronic exposures of 20 r or more per exposure for 50 exposures cause detectable weakening which like that following acute exposures is more severe with increasing dosage, shows a slower tendency to regenerate, less complete regeneration and more secondary weakening.

3. Similar total doses of acute and chronic roentgen exposure yield more severe initial changes in ridge details with acute than cronic exposure, less complete regeneration with chronic than acute exposure, and slightly more secondary weakening of ridge detail with chronic than acute exposure.

The results of these experiments are similar to those observed in humans, but the dose of roentgen rays necessary to produce minimal changes in monkeys and man may not be very close, for the skin on the volar surface of a monkey's finger is much tougher than that of a human.

MDDC-216 The Effect of Short Wavelength Radiations on Human Finger Ridge Detail, by *R. A. Harvey*, 33 p.

Atrophy of ridges of the fingerprint area were detected in 68% of radiologists, 55% of orthopedists who use a fluoroscope, 40% of dentists who hold films during exposure to X-rays and 1.8% of the controls.

The findings in professional groups were subclinical in a high percentage of cases, and they should not cause alarm if present standards of protection are appreciated.

Application of findings from the professional groups to industrial groups running possible hazard of radiation exposure in connection with the Manhattan Project was made. Although 20% of the material submitted from selected groups showed changes in ridge detail, the damage was detected in an early state and increased protection, re-evaluation of employee methods and rotation of personnel could be effected for employee safety.

MDDC-217 The Rate of Utilization of Cross-Circulated Platelets in the Thrombopenic Cat, by *J. S. Lawrence, W. N. Valentine*, 20 p.

1. The rate of utilization of blood platelets in radiated, thrombopenic cats has been measured directly. Thrombopenic animals, incapable of significant platelet regeneration, were cross circulated via carotid to carotid anastomoses with normal animals. After return to independent circulation the rate of disappearance of cross circulated platelets was measured by perodic counts.

2. By this method it was possible to elevate the platelet count anywhere from 100,000 to around 400,000 per cubic millimeter. The highest count obtained followed cross circulation with a splenectomized animal. In most instances the platelet level attained was within the physiologic range of that found for normal cats by the same method.

3. The cross circulated platelets gradually disappeared from the circulation over a two to a slightly more than four day period. Under the conditions of this experiment the entire platelet mass would have to be replaced therefore every two to five days. The same figures probably apply within narrow limits to the normal cat.

4. The average rate of platelet utilization was approximately 2500 per cubic millimeter per hour. In seven of eight experiments the rate of disappearance varied from about 1600 per cubic millimeter per hour to about 2800 per cubic millimeter per hour. In the experiment using a splenectomized donor the rate of disappearance was about double the average for the rest of the group.

5. Attention is called to possible therapeutic implications of these findings in idiopathic thrombopenic purpura.

MDDC-218 Preparation of Certain Chlorofluoro Derivatives of Ethylbenzene, by *E. T. McBee, et al*, 21 p. (See also *Industrial and Engineering Chemistry*, Vol. 39 No. 3 P. 384-386 March 1947).

Ethylbenzene was chlorinated photochemically to give phenylpentachloroethane and (chlorophenyl)pentachloroethane; upon further chlorination in the presence of ferric chloride at 140-160°C., these compounds were converted to (tetrachlorophenyl)pentachloroethane. Phenylpentachloroethane and (chlorophenyl) pentachloroethane were fluorinated at atmospheric and at superatmospheric pressures with hydrogen fluoride in the presence of antimony pentachloride to give compounds having 1, 2, and 3 chlorine atoms replace by fluorine. (Tetrachlorophenyl)monochlorotetrafluoroethane and (tetrachlorophenyl)dichlorotrifluoroethane were obtained by fluorination of (tetrachlorophenyl)pentachloroethane with hydrogen fluoride in the presence of antimony pentachloride at superatmospheric pressures. Chlorofluoro derivatives of phenylpentachloroethane and of (chlorophenyl)pentachloroethane were converted to (pentachlorophenyl)penta-(chlorofluoro)ethanes by chlorination in the presence of iron.

When (tetrachlorophenyl)perchloroethane and the (pentachlorophenyl)chloroperfluoroethanes were treated with antimony (V) fluoride, the principal products of the reaction were those formed by cleavage of the perhaloethyl group from the aromatic nucleus.

Chlorine was added to the aromatic nucleus of ethylbenzene; as a rule, from 4 to 6 chlorine atoms were added per molecule. However, when (tetrachlorophenyl)pentachloroethane was treated under similar conditions, it was not found possible to add more than two atoms of chlorine to the aromatic nucleus.

MDDC-219 Preparation of Polyhaloheptanes I. The Chlorination of *n*-Heptane, by *E. T. McBee, et al*, 13 p. (See also *Industrial and Engineering Chemistry*, Vol. 39, No. 3, P. 305-309, March 1947).

Polychloroheptanes containing about 83% chlorine corresponding to the average formula $C_7H_4Cl_{12}$, were prepared by the liquid phase photochemical chlorination of heptane at about 100°C. The reaction time was decreased by chlorinating at 75 lb/sq. in. Continued chlorination after Cl content reached 83% resulted only in chlorinolysis. Catalysts gave no increase in the rate or degree of chlorination under the conditions studied.

MDDC-220 Preparation of Polyhaloxylenes III. The Preparation of Polychloro-Bis(Trichloromethyl)-Benzenes, by *E. T. McBee, et al*, 17 p.

Mixtures of bis(trichloromethyl)benzenes were chlorinated readily to mixtures of polychloroxylenes having the average formula $C_8H_2Cl_8$. Trichloro-bis(trichloromethyl)benzene was the most highly chlorinated derivative isolated, and it seems conclusive that substantially no tetrachloro-bis(trichloromethyl)-benzene was obtained. Longer chlorination times and/or higher temperatures resulted in excessive chlorinolysis instead of increasing the degree of chlorination. The photochemical chlorination of tetrachlorodimethylbenzenes, prepared by the chlorination of *p*-xylene in the presence of iron, gave a product analyzing to have the approximate formula $C_8H_2Cl_8$. Further chlorination of this product resulted in the formation of chlorinolysis products.

MDDC-221 Semi-Popular Motion-Picture Record of the Trinity Explosion, by *J. E. Mack*, 46 p.

Still Photographs of the Trinity Test Explosion, Jornada Del Muerte, Alamogordo Air Base, New Mexico, 5:30 A. M., July 16, 1945.

MDDC-222 Control Equipment for 2.5 Mev Van de Graff Giving an Ion Beam Constant to ± 1.5 kev., by *J. L. McKibben, D. H. Frisch, J. M. Hush*, 8 p.

A degenerative control system having above characteristics is described. The system used is about 15 times better than was previously possible by regulating the charging current on the belt because use was made of a variable corona leak to the high potential electrode. The improvement resulted as the ions formed by the corona could cross the high voltage gap in 1/150 second rather than 1/10 second required by the belt. The leakage current can be varied from 50 to 150 microamperes by varying the potential on 4 needles projecting about 1/4" through 1/2" holes by means of a H & K 257 B pentode. The grid potential is controlled by an amplifier connected to a pair of pickup plates on the electrostatic analyser similar to that used by Hanson. The design of the focussed analyser is discussed. The 40 kv supply for the analyser is powered by a specially regulated 400 cycle generator. Constancy of voltage has been checked by measurement on Li(p,n) near threshold, and by an amplifier capacity coupled to the high potential electrode.

MDDC-223 **Nomographic Charts for Nuclear Reactions, by *J. L. McKibben*, 6 p.**

Use of artificial neutron sources made it convenient to have charts relating neutron energy, laboratory or center of gravity angle, and bombarding energy. Such charts are given for $Li^{7}(p,n)$, D(D,n), and $C^{12}(D,n)$ reactions.

MDDC-224 **Mechanical Fluorine Compression, by *R. L. Murray, S. G. Osborne, M. M. Brandegee*, 8 p. (See also *Industrial and Engineering Chemistry* Vol. 39. No. 3, P. 273-274, March 1947).**

A mechanical pump for the compression of fluorine was developed, based on two or more pulsating diaphragms hydraulically connected by liquids relatively inert to fluorine, and operated by a commercial reciprocating pump through the medium of a petroleum oil. Two such pumps were installed and have been operated successfully for over a year and a half.

MTDC-225 **Preparation of Xylene Hexafluoride, by *R. L. Murray, W. S. Beanblossom, E. H. Wojcik*, 22 p.**

A method suitable for the commercial manufacture of xylene hexafluoride and chloro-derivatives thereof was developed and successfully applied to the production of this material. The process consisted of chlorination of xylene to xylene hexachloride, pressure hydrofluorination of xylene hexachloride to xylene hexafluoride and recovery of xylene hexafluoride and useful by-products by rectification.

MTDC-226 **The Determination of Radium in Excreta, Volume 20B-6, by *E.R.Russell, G. W. Reed, Jr.*, 18 p.**

It has been found possible to separate tracer quantities of radium from the converted salts from urine by a solvent extraction method using isoamyl alcohol with barium bromide as a carrier. The method consists essentially of coprecipitating radium from an ashed urine solution with calcium carbonate, converting the carbonates to the bromides, and dissolving the salts in 100 ml of isoamyl alcohol saturated with barium bromide. The radium bromide which is dissolved in the alcohol along with the calcium bromide is coprecipitated with barium bromide by adding ether. The precipitate is mounted and counted in an alpha counter.

Several other procedures are also described for the determination of radium in excreta and are satisfactory for separating the element from all of its disintegration products.

MDDC-227 The Transuranium Elements, by *G. T. Seaborg*, 20 p. (See also *Science*, Vol. 104, P. 379-386, 1946).

The first isolation of Np, Pu, Am and Cm, their properties and the ultramicrochemical technique developed in connection with this work are developed. The amounts of the elements available ranged from less than 1 γ to 1 mg. The elements 89-96 are added to the periodic table as an actinide series in which the 5f electron shell is being filled. Atomic nos., atomic weights, activities, and half-lives are tabulated for the isotopes of Th, Pa, U, Np, Pu, Am, and Cm.

MDDC-228 Capture Cross Sections of I^{127}, In^{115}, Ag^{109}, Au^{197}, Ag^{107} for Neutrons of Various Energies, by *E. Segre, K. Greisen, G. A. Linenberger, T. A. Niskel, et al*, 6 p.

Tables listing values of the capture cross section measured at Los Alamos by use of neutrons from the Li(p,n) and D + D reactions. The values have been measured by comparing them with the hydrogen cross section. Graphs for the values listed are included.

LADC-229 **Lithium, Proton Neutron Reaction, by *R. F. Taschek*, 8 p.**

The present work was undertaken to accurately measure the $Li^7(p,n)Be^7$ reaction cross-section as a function of proton energy and to determine the angular distribution of the neutrons over as large an energy interval as possible with the Los Alamos generator.

The reaction cross-section was measured at 1.95 Mev and 2.25 Mev by use of a large manganese bath calibrated with two different standard Ra-Be sources. The following method was used:

1) The activity of a standard liquid sample withdrawn from the bath immediately after either natural source or lithium source irradiation was followed with a thin walled Geiger counter immersed in the solution;

2) The thin lithium targets which were uniformly evaporated on 10 mil tantalum backing material were weighed to determine the mg/cm^2 of lithium present.

Then from (1) one can calculate the neutrons per μcoul from the lithium target in question in terms of the standard source strength and combining this information with the amount of lithium on the target gives the reaction cross-section.

After correction for leakage of the Ra-Be neutrons from the 29" cube manganese bath the following cross-sections were obtained.

$$E_p = 1.95 \text{ Mev}, \sigma(1.95) = 0.242 \pm 3.5\% \times 10^{-24} cm^2,$$

$$E_p = 2.25 \text{ Mev}, \sigma(2.25) = 0.502 \pm 2.5\% \times 10^{-24} cm^2,$$

where the errors are mean deviations of four exposures or three targets.

Angular distribution of neutrons from this reaction are plotted.

MDDC-230 **Luting for Pipe Threads in Fluorine Lines, by *C. E. Weber, W. B. Burford, III, B. W. Lewis, S. B. Bitterlich*, 6 p.**

Various lutings for pipe threads in fluorine systems have been tested under actual service. A commercial product, Permatex-2, was found satisfactory, and while other lutings tested gave gas-tight seals with possibly less contamination of the gas, thread removal was impossible.

MDDC-231 **The Liquid Drop Model for Nuclear Fission, by *K. D. Present, F. Reines, J. K. Knipp*, 3 p. (See also *Physical Review*, Vol. 70, Nos. 7-S, P. 537-558, Oct. 1946).**

The calculations of Bohr and Wheeler have been extended in determining the potential energy as a function of the deformation parameters and in determining the saddle point giving the activation energy for fission. The critical shape of a nucleus with $x \gtrsim 0.80$ is symmetrical according to the liquid drop model. However the possibility is not excluded that for some large deformation beyond the critical shape, the contribution of the odd harmonics may change sign and the fission path deviate from symmetry. Since the cores of uranium and plutonium fission lie so close to $x = 0.80$, it is highly probable that the critical shape of these nuclei is symmetrical on the liquid drop model.

An attempt has also been made to calculate the lifetime against spontaneous fission from the Gamow formula. The multiple integral over the coordinates of all nuclear particles is transformed into an integral with respect to the deformation parameters a_n. The Jacobian of this transformation is evaluated from the velocity potential for a streamline motion of nuclear particles. The results are atvariance with experiment in predicting too short a lifetime for U^{235}.

MDDC-232 Gold Cross Section for Neutron from 0.01 tc 0.3 Ev, by *E.E.Anderson, L. S. Lavatelli, B. D. McDaniel, R. B. Sutton*, 7 p.

The cross section of gold has been measured by a transmission experiment using the time of flight method. If the scattering cross section is constant, the absorption cross section follows the 1/v law between 0.1 ev and .3 ev. The total cross section at .0250 ev is 104 ± 2 barns. Using the extrapolated value of 10 barns for the scattering cross section, one finds that the absorption cross section at .0250 ev is 94 barns.

MDDC-233 Parallel-Plate Alpha Counting System, Mark 6, Model 30A, by *Argonne National Laboratory*, 2 p.

This is an instrument for counting alpha samples usually evaporated on flat metal disks. The instrument makes use of a pulse ion chamber, an amplifier, pulse-height selector, scaler, and a regulated high voltage supply.

A circuit diagram of the instrument is included.

MDDC-234 The Titrimetric Determination of Thorium, by *C. V. Banks, H. Diehl*, 16 p. (See also *Analytical Chemistry*, Vol. 19, No. 4, P. 222-224).

A new oxidimetric method for the titrimetric determination of thorium is described. This method is based on the precipitation of thorium as the normal molybdate followed by the reduction and titration of the molybdenum equivelent to the thorium. This method has been applied to the separation of thorium from calcium and uranium and to the determination of molybdenum by reversal. A new electrometric method is described in which the thorium is titrated with ammonium paramolybdate in a 7 per cent acetic acid solution at 50° -55° with a 0.1 *N* calomel-molybdenum wire electrode system.

MDDC-235 Characteristics of Some Commercial Photomultiplier Tubes under Pulse Conditions, by *H. S. Bridge*, 11 p.

The measuring equipment for determining the characteristics of some commercial photomultiplier tubes under pulse conditions, consisted of the multiplier tube with necessary voltage supplies and meters, a pulsed light source, a Synchroscope, and a black cellotex tube of rectangular cross section 11 by 12 inches, 3 feet long. The multiplier tube and light source were arranged inside the black tube so that their relative position could be varied by known amounts.

In making measurements the voltage drop across the anode load resistor was observed on the oscilloscope and its magnitude read directly by determining the vertical deflecting voltage required to displace the pulse its own height. The current can then be calculated from the pulse height in volts and the resistance R_L of the load resistor. In all cases it is important that the voltage drop across the load resistor does not reduce the anode voltage enough to cause nonlinearity. For currents of the order of 50 ma the anode voltage should be at least 150 volts.

Actual observed pulse shapes agree quite well with the supposition that the light pulse is square. Some of the first data were taken with $R = 7.5 \times 10^3$ ohms and $C = 75 \times 10^{-12}$ farads. Under these conditions the pulse rose, in what looked like an exponential, to a point and decayed exponentially. When R was reduced to 1000 ohms the top of the pulse was flat showing that C had been charged to nearly its final value.

(Cont'd on next page)

MDDC-235 Characteristics of some Commercial Photomultiplier Tubes under Pulse Conditions, by *H. S. Bridge*, 11 p. (Cont'd from page 128).

For this case $I = I_o$ and no correction is necessary for the charging current to the condenser. Assuming that the current from the multiplier tube was the same at equal values of $1/R^2$, I_o from the 1000-ohm data was used to calculate I for the higher-resistance case using the measured rise times. Good agreement was found. The total output capacity was then reduced to 34×10^{-12} farads and resistance values used which allowed the current to be measured directly from the height of a flat-topped pulse.

The maximum average current observed during a run was 0.2 ma, so that the tubes were operated well within their average ratings. At the observed duty cycle this average current is somewhat too high. Perhaps a small tail on the pulse could account for this. The dark current, due to the small illumination present in the darkroom, was measured as 2 μamp. As it does not seem that the measured values of peak current can be in error because of this discrepancy, the cause has not been determined.

MDDC-236 Neutron Diffusion - Spherical Harmonics Theory, by *B. Carlson*, 85 p.

Approximate solutions of the Transport Equation are obtained for a large class of problems in neutron diffusion, using the Spherical Harmonics Method. This method gives rise to a sequence $\{\psi_{n-1}\}$ of approximations, the accuracy of which increase with n.

The polynomials closely associated with the Spherical Harmonics Method are investigated, in particular their asymptotic properties. The latter make it possible to obtain exact solutions by letting n approach infinity. Matrix representations of the general solutions (of order n) are developed which greatly reduce the analytical and numerical work connected with particular solutions. At the same time the discussion of boundary and other physical conditions is simplified. Some results obtained previously by the "integral theory" methods of Placzek, Frankel, Mark, and others, are derived by letting n approach infinity in the Spherical Harmonics approximations of order n. It is likely that "integral theory" results in general can be obtained by the methods of this report.

MDDC-237 Energy of the Hard Gamma Rays of La^{140}, by *W. Deutsch*, 6 p.

The energy of the hard gamma rays from La^{140} has been measured by the method of coincidence absorption of Compton electrons. The vast majority of the gamma rays have an energy of 1.69 ± 0.12 Mev. There is some evidence for a feeble group with energy above 2.5 Mev. This group, if it exists, must have an abundance of less than 0.03 of that of the main group.

MDC-238 Note on a Use of Delay Lines in Counter Pulse Amplifiers, by *O. R. Frisch*, 4 p.

A delay line is used to bring a pulse disturbance quickly back to zero, thus permitting more rapid counting than usual and helping to eliminate low-frequency interference.

MDDC-239 Calibration of Cadmium-Covered Gold Foils in a Graphite Block,, by *E. D. Klema*, 6 p.

Gold foils, 2 mils thick and 4 x 6.5 cm in area, covered with 32-mil cadmium, were calibrated by measuring their saturation activity as a function of distance from a known Ra-Be neutron source in a graphite block. For the particular counting geometry used, the following expression was determined: nv/unit logarithmic energy interval = (.0463) (saturation activity in counts/minute).

MDDC-240 Tolerance Concentrations of Radioactive Substances, by *K. Z. Morgan*, 32 p.

A review of some of the elementary equations and procedures involved in determining tolerance concentrations of radioactive substances when taken into the human system. This work is discussed from the viewpoint of methods of radioactive intake and elimination, background radiation, tolerance limits of radiation, nomenclature of radiology, long-lived radioactive elements in the body, short-lived radioactive elements in the body and chain products in the body.

A general discussion of problems illustrating the use of equations derived in the foregoing subjects is included.

MDDC-241 **The Transport Cross Section of Helium for Fast Neutrons**, by *P. Olum, V. F. Weisskopf*, 5 p.

On the basis of experimental work by Staub and others on the back-scattering of neutrons by helium between 0.5 and 2 Mev, which shows resonance peaks at about 1 and 1.2 Mev, Bloch has given a Breit-Wigner formula for the cross section in this region. After generalization of this formula to energy regions outside the immediate resonance, there is here derived from it an expression for the transport cross section of helium, which is also shown graphically for reasonable values of the experimental constants.

MDDC-242 **Instrumentation of the Hanford Engineer Works**, by *W. P. Overbeck*, 7 p.

Instrumentation problems at Hanford Engineer Works fall into four main groups:

1. Water Plant Instrumentation - To control purification and flow of large quantities of water and to insure continuous flow and proper distribution through all parts of the pile.
2. Pile Instrumentation - To monitor operation of the pile and to activate safety controls in the event of abnormal conditions.
3. Chemical Process Instrumentation - To aid remote control of chemical operations and to analyze samples.
4. Health Instrumentation - To protect workers from the hazards of handling radioactive materials.

General non-technical discussion of the complexities of the above-mentioned problems and of the program set up to train instrument personnel is also included.

MDDC-243 High-Efficiency Neutron Counter for Fast Coincidence Measurements, by *T. M. Snyder*, 2 p.

The scheme employs for neutron detection hydrogen recoils in a hydrocarbon-gas-filled proportional counter. The high efficiency is obtained by using a high filling pressure. The short electron-collection time for accurate coincidence measurements arises from the small counter diameter. In methane $\alpha = 15 \times 10^5$ cm/sec, 7.5×10^5 cm^2 mm Hg/sec volts this particular counter has an outer diameter of .65 cm, a wire diameter 5×10^{-3} cm, $V_o = 3000$ volts and p = 200 cm of Hg. This gives $t = 1.2 \times 10^{-7}$ seconds, rather good for coincidence work.

The multiplication is about 100. When filled with C_3H_8 an efficiency of 1% is obtainable.

MDDC-244 Estimation of Small Quantities of Uranium in Thorium, by *S.I.Weissman, R. B. Duffield*, 4 p.

Estimation of the intensity of the uranyl fluorescence furnishes a method for the determination of quantities of uranium as low as one-half microgram of uranium in one-half milliliter of glassy phosphoric acid. The test has been used to detect directly three parts of uranium in one million parts of thorium.

MDDC-245 Alpha Chamber Modified. 10 p.

Circuit diagrams of instrument.

MDDC-246 Revised Alpha Chamber. 20 p.

Circuit diagrams of instrument.

MDDC-247 General Rules and Procedures Concerning Activity Hazards, by *J. E. Wirth*, 29 p.

This report sets forth the general rules and procedures concerning activity hazards from the standpoint of maximum permissible exposure tolerances, radiation monitoring, protective clothing and devices, eating and smoking rules, contamination of persons and areas, the storage, handling and disposal of radioactive materials and a summary of responsibilities for the enforcement of radiation rules.

MDDC-248 Metabolism of Inhaled Fission Product Aerosols, by *R. Abrams, H. C. Seibert, A. N. Potts, W. Lohr, S. Postel*, 109 p.

This paper deals with the metabolism, in rats, of air-borne fission products. Four different isotopes were used, selected for their long lives and as representatives of the various chemical species occurring in fission. There were Sr^{89} (55 days), Zr^{95} (65 days), Y^{91} (57 days), and Ce^{144} (275 days). Aerosols of these materials were produced by atomizing aqueous solutions and by burning dried residues in a carbon arc.

Strontium differs from the other elements investigated in the ease with which it is absorbed from the lungs. Over 50 percent left the lungs within a matter of minutes, and 95 percent was gone within 1 hour. Of the Sr^{89} originally in the lung, 60 percent was deposited in the skeleton in less than 4 hours, and after 12 hours the total radiation dose to the skeleton exceeded that to the lungs. These results indicated that inhalation was as effective a means of administration as intravenous injection, and that lung damage as a result of inhalation of Sr^{89} would be of less importance than bone narrow damage.

The other three elements, Y, Zr, and Ce, may be grouped together insofar as they differ from Sr. They were all eliminated from the lung much more slowly than was Sr. Thus the times required for 90 percent elimination were: Y^{91}, 12 days; Zr^{95}, 25 days; and Ce^{144}, 45 days. In all cases the skeleton was the major site of deposition and eventually contained between 15 and 30 percent of the initial lung deposit. In no case, in periods ranging up to 200 days, did the total radiation dose to the bone exceed that to the lung, as it did within 12 hours with Sr. With all three elements the probability of radiation damage to the lung is great.

Very little deposition occurred in the soft tissues. The kidney, contained about 0.5 percent of the dose with all the elements. Concentration in the liver was lower than in the kidney with all isotopes except Ce^{144}. This element showed a very high initial liver deposition, but this was gradually eliminated so that after 2 months the liver concentration fell below that in the kidney.

MDDC-249 **The Pathological Anatomy of Uranium Poisoning, by** *T. B. Barnett, R. G. Metcalf*, 61 p.

The principal pathological change in experimental animals administered uranium compounds is necrosis of the renal tubular epithelium involving predominantly the proximal convoluted tubule. Evidence is offered which suggests that the region of the junction of the middle and distal thirds of the proximal convoluted segment is damaged exclusively with low doses and first and most severely with higher doses, except in the case of large injected doses where the first damage apparently occurs more proximally.

Degenerative changes first appear as early as a few hours after very large injected doses or as late as 2 to 4 days with moderate and small doses by inhalation and ingestion. The peak of epithelial necrosis is apparently reached within from 3 to 6 days following the initial exposure.

In animals surviving the initial injury, epithelial regeneration is observed within 1 to 2 days after the appearance of degenerative changes. Regenerated epithelium may be of one of two types, one of which approaches the normal in form while the other is flattened and atypical. In general, the latter occurs following rather severe damage. There is presented a discussion of the possible significance of these types of epithelium as regards their origin in the nephron.

Injury in the acute phase, comprising both degenerative and regenerative processes, produces the greatest overall change in the kidney in the period from the 5th to the 10th day following the initial exposure. This acute phase has not been observed to recur in animals subjected to repeated daily exposure by inhalation or to diets containing uranium compounds. Evidence is offered which suggests that there may be a return to a normal morphological condition following rather severe renal tubular injury in rats which are not re-exposed.

The changes in the chronic phase of uranium poisoning, as observed in rats fed uranyl nitrate as 2% of the diet for varying periods up to 2 years, are tubular atrophy, dilation, and distortion with an apparent slight increase in intertubular connective tissue and mild interstitial accumulation of chronic inflammatory cells. Such interstitial changes are also frequently observed in dogs and rabbits exposed to uranium compounds for 30 days.

The results of a preliminary study of acquired tolerance to uranium in rats are presented. These results indicate that prolonged exposure to uranium may produce conditions under which injection of an ordinarily damaging dose of uranium results in no appreciable renal tubular necrosis.

Under the conditions of exposure employed, glomerular changes are observed infrequently. Hyperemia and swelling occur occasionally and glomerular necrosis very rarely during the acute stage of uranium poisoning following very high dosage exposure.

Pathological changes in organs other than the kidney which may result from uranium exposure are as follows: 1) Degenerative changes in the liver cord cells of dogs dying during exposure to high dietary and atmospheric concentrations. 2) Mucosal and submucosal hemorrhages in the gastro-intestinal tract of dogs fed large doses of uranium compounds. (Cont'd on next page)

MDDC-249 The Pathological Anatomy of Uranium Poisoning, by *T. B. Barnett, R. G. Metcalf*, 61 p. (Cont'd from page 136).

3) Pulmonary hemorrhage and edema in rabbits dying during exposure to high atmospheric concentrations of certain uranium compounds. Severe pulmonary irritation in animals exposed to high atmospheric concentrations of uranium hexafluoride is attributable, at least in part, to one of its decomposition products, hydrogen fluoride.

MDDC-250 Studies on the Effects of Massive Doses of Roentgen Radiation on Mortality in Laboratory Animals, by *R. D. Boche, F. W. Bishop*, 13 p.

The object of these experiments was to supplement the existing literature on the effects of single acute exposures of animals with a view to forming an estimate of what variations exist among different mammalian species. The applicability to man is uncertain but one may assume as a first approximation that his sensitivity lies within the range of other species. Systematic studies have been made on the behavior of peripheral blood elements in the rat, dog and monkey following single exposures. Tissue studies on animals sacrificed serially have been carried out for the rat and fairly complete histology has been done on animals at death.

It is now well established that curves relating mortality to dose are of the sigmoid type for most organisms studied and the mamals are no exception in this respect. Such sigmoid curves may be conveniently transformed to straight lines by the method of Bliss which is based on the assumption (a) of normally distributed susceptibility of the individuals radiated and usually (b) geometric increase in effect with increasing dose. Such straight lines provide the simplest method of estimating the median lethal dose for a given set of conditions and variations in LD 50's constitute a convenient basis for comparison of species or other factors. Mortalities and average survival times are tabulated and plotted for various animals given varying doses of Roentgen radiation.

MDDC-251 Tracer Studies with Inhaled Eight-Day Iodine, by *M. Dailey, I. Wender, R. Abrams*, 11 p.

Radioactive I^{131} was obtained from pile bombarded tellurium, from sump water from the extraction plant at Clinton Laboratories, and from fumes evolved from solution of a bombarded slug. An oxidizing agent (usually KIO_3 or H_2O_2 - $FeSO_4$) was added to a solution of radioactive iodide and iodine gas was thus evolved. The radioactive iodine gas was mixed with air and passed through a manifold from which 21 anaesthetized rats breathed. Tissues were wet-ashed for measurement of activity due to I^{131}.

Results of two experiments indicated that about 10 percent of the inhaled I_2^{131} was retained by the rats. Of that which was retained at the end of a 30 minute exposure only five percent was in the lung and some of this was probably in pulmonary blood. Hence absorption of I_2 from the lung was practically instantaneous. The thyroid contained 10 percent of the retained iodine at 48 hours; the remaining 90 percent was excreted in the urine. The fate of iodine absorbed from the lung is similar to that of ingested iodide.

MDDC-252 Catalasuria as a Sensitive Test for Uranium Poisoning, by *A. L. Dounce, E. Roberts, J. H. Wills*, 106 p.

Report demonstrates that an abnormally high excretion of catalase occurs in the urine of rabbits, dogs, cats, and probably rats after the poisoning of these animals with high or low doses of uranium compounds, whether administered by parenteral injection or by inhalation.

The increase in catalasuria following uranium poisoning coincides in time with the appearance of demonstrable amounts of protein in the urine. The urinary catalase and protein values go through maxima usually from 3 to 6 days after the administration of soluble U_6 compound by injection. If the uranium compound is administered by inhalation, these maxima may be delayed and of longer duration.

The catalase maxima occur at the time of maximum breakdown of renal tubular cells and result from an escape of the enzyme catalase from the damaged cells. An earlier maximum has been observed in acute injection experiments which appears within 2 to 3 hours after the intravenous injection of large amounts of uranium compounds. The significance of this earlier maximum is not certain.

The appearance of catalase in the urine after exposure to uranium compounds in animals is an extremely sensitive test for kidney tubular damage by uranium. In rabbits the catalase test is more sensitive than the urinary protein test, and this is probably true in cats also. In the case of dogs the catalase test is more sensitive than the protein test in some animals and less sensitive in other animals. The catalase test is preferable to the phosphatase test because it is more reproducible after repeated doses of uranium compounds.

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MDDC-252 Catalasuria as a Sensitive Test for Uranium Poisoning, by *A. L. Dounce, E. Roberts, J. H. Wills*, 106 p. (Cont'd from page 138).

In general, catalasuria and proteinuria are the most sensitive indicators of the acute stage of tubular damage to the kidneys. The combination of the catalase and protein tests furnishes an advantage over the protein test alone, not so much because of the greater sensitivity but rather because of the greater specificity.

The appearance of abnormally high catalasuria is a specific indication of tubular damage to the kidneys, while the appearance of proteinuria may be an indication of glomerular damage alone, or glomerular plus tubular damage. Even in rather severe uranium poisoning, plasma catalase, because of its high molecular weight, does not filter through the glomerulus.

Other agents besides uranium which attack the tubules such as mercuric chloride, mapharsen, sodium tartrate, and potassium dichromate have been found to produce catalasuria. Adrenalin on the other hand does produce a slight proteinuria without any catalasuria. The same is true of heavy exercise, fright, and probably alcohol.

MDDC-253 The Mechanism of Action of Uranium Compounds in the Animal Body, by *A. L. Dounce*, 73 p.

Bone ash has a remarkable affinity for uranium. It adsorbs uranium almost equally well from serum, serum ultrafiltrate, and bicarbonate buffer.

With increasing concentrations of uranium in solution, greater quantities of uranium but smaller percentages of the total uranium are taken up by bone ash in a manner described by the Freundlich adsorption isotherm. However, a sharp loss in uranium from solution appears to occur at high uranium concentrations, due possibly to the precipitation of some insoluble uranium compound.

With increasing concentrations of bicarbonate at constant concentrations of uranium, smaller quantities as well as smaller percentages of the total uranium present are taken up by bone ash.

With increasing pH, the uptake of uranium by bone ash decreases. The possible significance of these results in regard to physiological findings is pointed out.

MDDC-254 Observations on Animals Exposed to Whole Body Roentgen Radiation in Divided Doses over long Periods, by *A. H. Dowdy, R. D. Boche, F. W. Bishop*, 22 p.

This report discusses only the routine and the techniques that were used in radiating laboratory animals over a long period of time in order to determine whether the accepted tolerance levels for exposure of persons to Roentgen and Gamma radiation are adequate to insure a reasonable degree of safety. The general objective of the experiments described was to determine whether there exists any exposure level to which animals may be subjected without the manifestation of any deleterious effects, and if so what this level of radiation exposure is, and which organ system is the most sensitive to chronic radiation injury. Actual results are reported elsewhere.

MDDC-255 The Purification and Compression of Fluorine, by *R. C. Downing*, 17 p.

Fluorine was packaged at a pressure of 400 lbs/sq in. by first condensing at the temperature of liquid nitrogen and then vaporizing into evacuated nickel cylinders.

The gas was compressed mechanically to a pressure of 175 lbs/sq in. Higher pressures could probably be reached in a multi-stage system.

Before condensation, hydrogen fluoride was removed from the fluorine by refrigeration at -78°C. followed by reaction with sodium fluoride.

The hazards of working with fluorine under pressure were recognized, and a series of tests led to some general conclusions regarding safe working methods.

MDDC-256 Total Cross-Sections Measured with Photo-Neutrons, by *R. Fields, B. Russell, D. Sachs, A. Wattenberg*, 16 p. (See also *Physical Review*, Vol. 71, No. 8, P. 508-510, April 15, 1947).

The total neutron cross section of twenty-three elements have been measured using six photo-neutron sources ranging from 0.024 Mev to 0.83 Mev. The cross sections of the lighter elements behave very anomalously; broad resonances in the scattering are observed in F, Na, Mg, Al, and S. Nickel has the exceptionally high cross section of 23×10^{-24} cm^2 at 0.024 Mev. The cross sections of elements of atomic weight about 110 show very little variation with energy and are about 7×10^{-24} cm^2. The heavy elements have cross sections of about 13×10^{-24} cm^2 at 0.024 Mev and decrease monotonically to about half that value at 0.83 Mev.

MDDC-257 Tolerance to Uranium Compounds, by *F. Haven*, 52 p.

Species differences in mortality following the administration of uranium nitrate by three different routes clearly indicate the existence of a striking natural tolerance to this compound. The rat possessed less natural tolerance than the mouse and the white mouse far less than the C_3H mouse.

On the basis of mortality following a test dose, male rats have been shown to possess more natural tolerance and to develop greater acquired tolerance to uranium nitrate than do female rats, which may be related to the fact recognized earlier that females retained a greater percentage of the dose in the kidney than males of the same age. Neuman's work (MDDC-264) on distribution and excretion of uranium in the rat has confirmed this finding and has added the fact that male rats of the same weight store more uranium in bones than female rats, thus sparing the kidney.

The work on acquired tolerance shows that either the method of repeated doses or the method of increased doses may be used to produce tolerance in rats. The small dose used in the method of repeated doses should probably be large enough to cause considerable functional injury to the kidney in order to produce tolerance. The slight changes in body weight following repeated doses too small to produce tolerance and the greater changes following doses which produced tolerance would indicate that kidney damage is a prerequisite to tolerance. The markedly increased ratio of kidney weight to body weight and the concomitant decrease in dry residue, the absence of kidney phosphatase, the high urinary volumes and the low variable pH's are all indicative of kidney damage in tolerant rats. (Cont'd on next page)

MDDC-257 Tolerance to Uranium Compounds, by *F. Haven*, 52 p. (Cont'd from page 141).

The average body weight data for adult rats made tolerant by the repeated dose method show that the initial body weight is exceeded by about the time of the ninth injection. Concurrently the urinary excretion of citric acid during repeated dosage is at its height. The excretion of citric acid remained normal after the repeated administration of a dose of uranium nitrate (0.1 mg/kg) too small to cause tolerance to the test dose. By the method of increased dosage the 10 day interval was better than the 20 day interval for producing tolerance. At 10 days after a single injection the excretion of citric acid had begun to rise while at 20 days the excretion was falling. Each time an increased dose was given at 12 day intervals the excretion of citric acid was high .

These facts are in agreement with the hypothesis that the enhanced urinary excretion of citric acid following administration of uranium is concerned with tolerance. As pointed out, no increase in urinary excretion of uranium by tolerant rats was found, which may be accounted for by the wide variation in excretion from animal to animal following a single dose. The kidneys of tolerant rats retain less uranium than those of non-tolerant animals, a fact which may be explained by assuming that uranium having filtered through the glomerulus as the bicarbonate complex combines with citric acid present in the tubule and is excreted. In the absence of citric acid uranium would combine with protein of the tubule and cause kidney damage.

The available evidence indicates that the presence of citric acid in the kidney tubule in concentrations above normal may account for acquired tolerance to the toxic action of uranium.

MDDC-258 **Toxicity Following the Parenteral Administration of Certain Soluble Uranium Compounds,** by *F. Haven, H. Hodge,* 55 p.

RATS

Doses of 4 to 5 mg/kg of uranium nitrate produced in young Wistar rats mortalities of about 65% for males and 95% for females.

Doses of 5 to 6 mg/kg of uranium nitrate in adult Wistar rats gave mortalities of about 50% in males and about 95% in females.

Doses of 2.5 mg/kg of uranium oxyfluoride in male Wistar rats gave mortalities of 20%. In female rats the mortalities were 95%.

A dose of 25.0 mg/kg of UCl_4 gave a mortality of 90% in adult male and female rats. There is an increase in toxicity with increasing age.

MICE

Doses of 4 to 32 mg/kg of uranium nitrate gave an approximate LD50 of 6 to 8 mg U/kg in white mice.

Doses of 4 to 150 mg/kg of uranium nitrate in male and female C_3H mice gave an approximate LD50 of 20 to 25 mg U/kg.

The approximate lethal dose in mg U/kg of a uranium nitrate solution administered intravenously in 4 species of animals is as follows: Rabbits - 0.1, guinea pigs - 0.3, rats - 1.0, mice - 10-20.

MDDC-259 **The Biologic Effects of Pile Radiations, by *P. S. Henshaw, E. F. Riley, G. E. Stapleton*, 24 p.**

A variety of high energy radiations (fast and slow neutrons, gamma rays, beta rays, etc.) are associated with the uranium chain reaction in a pile reactor. All of these radiations are known to cause deleterious biological effects and hence constitute health hazards.

In an attempt to better understand the types of injury induced and at the same time obtain information on threshold and tolerance levels, numerous animal experiments were carried out. Four strains of mice (CF_1, ABC, A, C58) and one strain of rats (Sprague-Dawley) were the main types of test material. The different radiations were obtained by means of selective filtration, secondary emitters and radioactive isotopes. Single massive dose treatments as well as small daily treatments were administered. The radiations used, with the exception of beta rays, were of the penetrating type, and for the most part were distributed throughout the animal bodies. Results revealed that the length of life varied inversely with the amount of exposure, and further that the amount of effect varied directly with the concentration of ions in space and time.

MDDC-260 **Comprehensive Summary of the Pharmacology and Toxicology of Uranium Compounds. Chapter XVI. Studies on Human Exposures to Uranium Compounds, by J. W. Howland, 42 p., July 1, 1946, decl. March 26, 1948.**

This chapter is divided into five major parts: (1) A review of the literature is presented in which the clinical use of uranium as a drug in the treatment of disease in the years 1874 to 1930 is described. (2) An historical description is included next of the selection of 150 $\mu gU/m^3$ as a temporary maximum allowable concentration. (3) Some of the factors known to be important in exposures to dusts are presented and their influence indicated. (4) Reports are made in considerable detail of two accidents in which workers were exposed to flood concentrations of uranium hexafluoride. Case reports are included, both of fatal and of non-fatal cases. (5) A careful outline is presented of the program of medical observations conducted by the medical branch on workers in laboratories and plants in which chronic exposures to uranium compounds were possible. The description included pre-employment examinations and periodic health check-ups with laboratory procedures. A special program of industrial hygiene was set up at four selected sites: (a) a large laboratory, (b) a small uranium processing plant, (c) a large ore and uranium processing plant, and (d) a large uranium processing plant. In addition, two programs of special examinations were carried out; one on 10 men working in a UF_6 plant, and the other on 31 men with possible exposures to UO_3, UO_4, and UCl_4.

MDDC-261 **The Effect of Total Body X-Irradiation on a Pre-Existing Induced Anemia in Rabbits, Part I-The Response of Animals with a Phenylhydrazine-Induced Anemia,** *L. O. Jacobson, E. K. Marks, E.L.Simmons,* 22 p.

A regenerative anemia was produced in rabbits by the subcutaneous administration of phenylhydrazine hydrochloride. The hematological effects of 800 r total body x-irradiation on such anemic animals were compared to effects on normal untreated animals, on animals given phenylhydrazine and allowed to recover spontaneously, and on a group of animals which were given 800 r alone.

A characteristic initial rise and subsequent reduction in leucocytes and heterophils and an immediate precipitous fall in the lymphocyte values followed the administration of 800 r in the group in which a regenerative anemia had been produced with phenylhydrazine, as well as in normal control animals. The times for recovery of these elements to normal limits in the two groups were roughly comparable. An "abortive" rise in the leucocyte values of both these groups was noted between the 5th and 11th days after irradiation.

The group of animals which received x-irradiation alone developed an anemia with its maximum at 14 days and recovery by 23 days. The animals in which a regenerative anemia was produced by phenylhydrazine and which was allowed to recover spontaneously had likewise returned to normal limits within 14 days.

The reticulocyte values of animals which received phenylhydrazine alone, after reaching a maximum, fell spontaneously to normal values within 2 days. The reticulocyte values of similar animals given 800 r at or near the time of the maximum reticulocyte response fell maximally within 2 days and reached a minimum of 0.8 percent, then recovered to normal limits by 9 days. Values of control animals which were given 800 r only fell maximally within 2 days, reached a minimum of less than 0.1 percent, and recovered by 23 days.

262. The Design of Radiochemical Laboratories, by *H. A. Levy*, 27 p. (See also *Chemical and Engineering News*, Vol. 24, No. 23, P. 3168-3173, Dec. 10, 1946).

Laboratory facilities for radiochemical research are classified according to the level of radioactivity involved in the operations. The classification microcurie, millicurie, and multicurie is a useful one. Problems often require manipulations at more than one of these levels; the prosecution of low-level work in the immediate neighborhood of high-level activities is to be avoided, and consequently separate facilities for work at more than one level may be needed in a single laboratory.

Microcurie level: Ordinary chemical facilities are satisfactory. Counting and other measuring instruments are best located in a constant temperature, shielded room.

Millicurie level: Shielding is needed between the operator and equipment, necessitating the construction of specially designed hoods. Vessels containing active materials can sometimes be manipulated from a distance by means of special tongs. Shielded vaults for stored samples and a waste-disposal system are necessities. Special apparatus for often-repeated operations, e.g., the removal of an aliquot from a solution, is desirable. Radiation-monitoring is required for safe operation.

Multicurie level: Manipulations must be completely remotely-controlled and carried out behind heavy, permanent shielding. Contamination of the laboratory and equipment by radio-active materials in quantities dangerous to personnel is a major problem. Drains and storage facilities for highly active waste liquors are required. Radiation-monitoring, preferably automatic, is essential, and an alarm system to indicate dangerously high radiation is desirable.

Work involving ponderable quantities of alpha-emitters of intermediate life (10^5 yrs. or less) presents special problems because of the high toxicity of the material.

MDDC-263 Studies of the Toxicity of Various Uranium Compounds when Fed to Experimental Animals, by *E. A. Maynard, H. C. Hodge*, 114 p.

As a result of 30 day feeding tests with rats the various uranium compounds can be classified as follows:

Non-Toxic	Toxic	
UO_2	UO_3	UCl_4
U_3O_8	UO_2Ac_3	UO_2F_2
UF_4	UO_4	$UO_2(NO_3)_2$

Twenty per cent of the 'non-toxic' compounds fed in the diets caused no mortality and very little interference with growth; 2 to 10% of the 'toxic' compounds caused 100% mortality and 0.1 to 1% of these compounds in the diet caused growth depression.

Mature rats were more susceptible to poisoning by U nitrate in the diet than were weanling rats.

The kidneys were the only organs that showed histological damage as the result of U poisoning under these conditions.

No significant hematological changes were found after feeding U compounds for thirty days.

In both weanling and mature rats, body weight depression and loss of appetite promptly appeared on the 1st day following the ingestion of 2.0% U nitrate in the diet.

Intake of the diet containing 2.0% U nitrate reached minimal values on the 5th to 12th days, accompanied by the expected mortalities.

After recovery from the initial effects of the U poisoning, the surviving rats overate an amount sufficient to compensate for the earlier period of fasting.

Four uranium compounds were fed to rats for two years, over which period of time the least amounts of the compounds that caused retardation of growth were determined as follows: UO_2F_2 - 0.1%; $UO_2(NO_3)_2$ - 0.5%; UF_4 - 20.0%. Twenty percent of UO_2, the highest level tested, produced no effect).

In general, the growth tendencies established by the rats in the latter part of the first year on diet were continued throughout the second year.

The life span of rats was not affected by the ingestion of uranium compounds at dietary levels as high as here indicated: UO_2F_2 - 0.25%; $UO_2(NO_3)_2$ - 2.0%; UF_4 and UO_2 - 20.0%.

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MTC-263 Studies of the Toxicity of Various Uranium Compounds when Fed to Experimental Animals, by *E. A. Maynard, H. C. Hodge*, 114 p. (Cont'd from page 147).

A series of tests of exploratory nature were carried out on a minimum number of dogs to ascertain the approximate lethal level of oral intake. Single dogs were fed a certain daily dose of one of the compounds under investigation. Within rough limits, the daily dose which could be ingested with survival for 30 days was established.

A considerable number of criteria of uranium poisoning were observed on dogs in 30- day feeding experiments. The following criteria proved the most useful: survival for 30 days, blood NPN, urea-nitrogen, and the histopathology of the kidney, liver and gastro-intestinal tract.

Using various criteria as a basis for determining the relative toxicities of the several uranium compounds, the following classification was made:

'Slightly Toxic'	'Moderately Toxic'	'Highly Toxic'
UF_4	U nitrate	UO_2F_2
U_3O_8	UO_3	UCl_4
UO_2	$Na_2U_2O_7$	UO_4
	$(NH_4)_2U_2O_7$	
	High-Grade Ore	

Dogs were more susceptible to uranium poisoning than were rats.

A few dogs were fed various levels of UO_2F_2, UCl_4 and U nitrate for one year. Additional tests of similar plan are currently in progress in which UO_2 and UF_4 are being fed.

Body weight losses were observed only in the two dogs fed the highest level of U nitrate. No body weight losses were observed at any of the other levels of any of the other compounds.

A number of criteria of uranium poisoning were observed. Evidences of poisoning were found in some one of these criteria when amounts greater than 0.02 g/kg/day are added to the diets.

A question of the existence of a cyclical pattern of chronic uranium injury has been raised which requires further experimentation to establish.

Small groups of rabbits were fed various levels of U nitrate in the diets.

At each level body weight losses were recorded; these were minimal in the rabbits receiving 0.02%.

All the rabbits receiving 0.5% of U nitrate died; none of the rabbits receiving 0.02% in the diet died.

Histological renal damage was observed at all dietary levels.

MDDC-264 The Distribution and Excretion of Uranium, by *W. F. Neuman*, 54 p.

Within the limits of the data at hand, a provisional, general synthesis of the fate of hexavalent uranium in the animal body may be made. A simplified diagram of the events which presumably take place is given.

(a) Uranium enters the blood stream via all routes of administration.

(b) In the blood stream, uranium exists mainly in two forms: a non-diffusible complex with the plasma proteins; and a diffusible complex with bicarbonate. Both forms are reversibly in equilibrium with each other.

(c) The bicarbonate-uranium complex enters the extracellular fluid bathing the soft tissues but it either does not penetrate the cells, or, if it does, is not 'fixed'. It therefore re-enters the circulation.

(d) The bicarbonate-uranium complex is filtered by the kidney glomerulus. If the blood level of bicarbonate is increased there is a relatively greater proportion of the uranium present as the diffusible bicarbonate complex; therefore, the rate of filtration of uranium is increased. If the alkaline reserve is high and a significant concentration of bicarbonate remains in the urine leaving the kidney, little uranium will combine with the protein surfaces of the tubules; most will be eliminated or reabsorbed. Conversely, if *all* of the bicarbonate is reabsorbed by the renal tubules, more of the filtered uranium will 'stick' to the tubules, thereby damaging cell surfaces; less will be excreted and less reabsorbed.

(e) At the same time these events are taking place in the kidney, the bicarbonate-uranium complex filters into the fluid bathing the bone. The mechanism whereby uranium is deposited in bone is not clear.

(f) In alkalosis, the distribution is shifted; less uranium is deposited in kidney, more is excreted in the urine. In acidosis, more uranium is deposited in kidney, less is excreted in the urine.

(g) Young animals, because of the extensive circulation throughout the skeleton deposit more of the dose in the bone system than do adults.

From the toxicological standpoint, the pharmacology of tetravalent uranium is less important than the pharmacology of hexavalent uranium. Primarily, this difference in pharmacological importance is due to the difference in chemical properties of the two valence forms. Because of its protein-affinity U_4 cannot pass a semi-permeable membrane. It is believed, therefore, that little uranium in the tetravalent state can enter the animal body except by direct injection. The distribution of U_4 was found to be quite similar to that of U_6. The one marked difference noted was that U_4 accumulated in the livers of the injected animals.

MDDC-265 The Toxicology of Compounds of Uranium Following Application to the Eye, by *J. A. Orcutt*, 14 p.

Eyes of rabbits were exposed to uranyl nitrate, uranyl fluoride, uranium trioxide, sodium diuranate, ammonium diuranate, uranium tetrachloride, uranium pentachloride, uranium tetrafluoride, uranium dioxide, uranium peroxide, and uranium tritaoctoxide. Moderate to severe local lesions and systemic poisoning were produced in most cases.

MDDC-266 The Toxicology of Compounds of Uranium Following Application to the Skin, by *J. A. Orcutt*, 66 p.

1. Uranyl nitrate, uranyl fluoride, uranium pentachloride, uranium trioxide, sodium diuranate, and ammonium diuranate may be absorbed through the skins of experimental animals to a sufficient extent to cause severe poisoning and death. Uranium has been found in the blood stream of rats following the dermal exposure to uranyl nitrate.

2. Uranium tetrachloride was also found to produce poisoning following application to the skin, but it is believed that oxidation to the hexavalent state is necessary before significant absorption will take place.

3. The insoluble oxides (UO_2, UO_4, and U_3O_8) and tetrafluoride (UF_4) caused no signs of poisoning following application to the skin.

4. Rabbits, rats, guinea pigs, and mice, in order of decreasing susceptibility, were poisoned by dermal exposure to uranyl nitrate. Species differences were significant, there being more than a hundred-fold difference in the LD50's of rabbits and mice.

5. Although the size of the dose required to produce poisoning varied among species, the general course of poisoning was the same for all species. In the case of rabbits, by the second day following acute exposure, the mean urinary protein was significantly positive and a few deaths had occurred. On the third day, the mean non-protein nitrogen of the blood became significantly elevated.

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MDDC-266 The Toxicology of Compounds of Uranium Following Application to the Skin, by *J. A. Orcutt*, 66 p. (Cont'd from page 150).

On the fifth day, urinary protein had reached a maximum, blood-NPN was very high, the mean body weight had dropped significantly, and mortality was highest. The mean NPN reached a maximum on the 9th day, when body weight was also maximally depressed and the mortality was still relatively high, but the mean urinary protein had fallen to only slightly positive values. Following the 10th day, mean values for all toxicological manifestations began to decrease rapidly and were essentially 'normal' by the 18th day following exposure, after which no deaths were observed.

Although blood-NPN determinations were not made for the other species, the pattern of urinary protein, body weight, and mortality was essentially the same as for rabbits. The details of minor differences are indicated.

6. Renal damage, characteristic of uranium poisoning, was observed microscopically in all of the animals that died and were examined. Survivors that had shown signs of severe poisoning, but had recovered, were found to have little histological evidence of renal damage, suggesting a remarkable ability for repair.

7. Repeated dermal exposures resulted in the toleration of cumulative doses that would have been quite lethal if applied as single exposures. Signs of poisoning in the survivors gradually disappeared or lessened, after some time, even though the repeated exposures were continued, suggesting an acquired tolerance in survivors.

8. Uranyl nitrate, uranium pentachloride, and uranium tetrachloride produced a mild to moderate, though transient, local irritation of the skin.

9. A number of detergents and 'protective coatings' were studied in an attempt to prevent the percutaneous absorption of uranyl nitrate but none proved to effect any significant protection.

10. Sodium bicarbonate or sodium bicarbonate plus hydrogen peroxide, in aqueous solution, was found to be most effective in removing toxic compounds of uranium from the cotton clothes of workers.

MDDC-267 **The Preparation of Morphologically Intact Leucocytes from Peripheral Blood (Part I)**, by *S. Schwartz, L. DeGrazia, K. Cheney, M.B. Hasenfus, S. Cohen*, 9 p.

A simple method is described for the rapid and apparently quantitative recovery of white blood cells from peripheral blood. It involves a ten-fold dilution of heparinized blood with about 0.03% saponin and 0.6% saline. Red cell hemolysis is complete within two minutes. The sample is centrifuged and the centrifugate is washed once with saline. After another centrifugation, a leucocyte preparation is obtained which is completely free of red blood cells.

MDDC-268 **The Administration of Radioactive Materials to Animals by Tracheal Intubation**, by *H. C. Seibert*, 7 p.

A procedure is described for cannulating rats so that radioactive materials may be introduced into the lungs without simultaneously depositing on the hide or in the upper respiratory tract. Descriptions are provided for the special cannulae and animal holder devised for the procedure.

MDDC-269 The Preparation of Morphologically Intact Leucocytes from Peripheral Blood (Part II), by *T. P. Singer, S. Schwartz, I. Silberbach*, 17 p.

A method involving the combined use of gramicidin and lysolecithin is described for the rapid and apparently quantitative isolation of morphologically intact leucocytes from circulating blood. The mixture of these two compounds gives rapid and complete lysis of erythrocytes.

The use of either gramicidin or lysolecithin alone in sufficient amount to completely lyse the red cells results in morphological damage to the leucocytes. For some as yet unknown reason, however, the combined use of these two agents in a definite ratio results in cancellation of this leucocyte damaging effect.

The preparation of both crude and purified lysolecithin from cobra venom is described along with a method of assay of hemolytic activity. Since investigation of the metabolic and biochemical properties of the isolated leucocytes has not yet been possible, authors are unable to say whether or not the isolated leucocytes are biochemically intact.

MDDC-270 An Apparatus for Maintaining a Slow and Constant Rate of Injection, by *R. H. Snyder, B. Lawrence, R. D. Finkle*, 10 p.

A machine is described which delivers ca 0.1 ml of solution per hour at a constant rate. The device proved satisfactory for the injection of a plutonium solution into the veins of rats. The results of a preliminary trial with three rats suggest that the rate of injection may be a significant factor in the metabolism of plutonium.

MDDC-271 Characteristics of Uranium Poisoning, by *J. Henry Wills*, 77 p.

Evidences of interference with the normal functions of both the liver and kidney in poisoning with uranyl salts have been found. In general the evidences of liver dysfunction have not been particularly marked, while those of kidney dysfunction have been quite striking and in general have preceded in time the appearance of liver effect. It appears possible that the kidney is the only parenchymal organ affected directly by uranium, and that the effects on other organs are consequent to the acidosis and azotemia, with attendant cachexia, induced by the kidney dysfunction. For this reason tests of kidney integrity seem the most pertinent to uranium poisoning as diagnostic aids.

Of the possible tests of renal integrity, the urinary excretions of catalase, protein, and phosphatase have the same significance: they indicate an active process of cellular breakdown within the kidney. Proteinuria may indicate also breakdown of some of the normal barriers between blood plasma and urine. In general, these tests show a sharp peak two to five days after the acute insult and usually return quickly to normal levels. Catalase appears dependably in the urine of the rabbit after single intravenous injections of 0.02 mg/kg of uranyl acetate.

The tests of functional capacity of the kidney tubule(phenol red removal from the blood, the ratio of the urinary excretions of amino acid nitrogen and creatinine, chloride and diodrast clearances, chloride reabsorption, and diodrast secretion) attain their maximal change three to six days after the acute insult by uranyl uranium. Even during continued exposure to uranium the kidney function returns toward normal if the exposure is not sufficiently great to produce rapid fatality. After heavy exposures the chloride clearance and the amino-acid nitrogen to creatinine ratio may remain elevated for appreciable periods of time after cessation of the exposure, indicating some prolonged interference with tubular activity. The ratio of the urinary concentrations of amino-acid nitrogen and creatinine has been found to be elevated consistently in rabbits by injection of 0.05 mg/kg of uranyl acetate and sometimes by injection of 0.03 mg/kg. The other tests of renal function have not been studied in this way, but their dosage sensitivity would be expected to be about the same as that of the ratio.

MDDC-272 The Absorption of Slow Neutrons by Indium, by *B. D. McDaniel*, 77 p.

A velocity spectrometer was built, to which new detector modulating equipment was added. In the new modulating equipment, the number of detecting channels was increased to twelve, and the equipment was designed to operate stably when "on" times as short as 5μ sec are used.

Neutron transmission measurements were made on indium absorbers over the range of energy extending from 0.015 to 80 ev. The thickest absorber which was used was 4.05 gm/cm^2 and the thinnest was 0.0227 gm/cm^2. Three other intermediate absorbers were also used.

In the range of energy stated, three resonances were observed. The strongest was located at 1.44 ev. A much weaker resonance was located at 3.7 ev and a still weaker resonance at about 9 ev. The shape of the resonance at 1.44 ev was well established and agreed well with the theory given by the Breit-Wigner one-level formula over the range from 0.015 to 2.5 ev. The following constants were chosen to represent the level.

$$E_R = 1.44 \text{ ev}$$

$$\sigma_o = 28.400 \times 10^{-24} \text{ cm}^2/\text{atom}$$

$$\Gamma = 0.085 \text{ ev}$$

$$\frac{(1 \pm 1)}{2j+1} \Gamma_M = 2.5 \times 10^{-3} \text{ ev}$$

Though it was estimated that the probable error in the total width of the level was 15 percent, the estimated probable error in the cross section is 25 percent and the probable error in the neutron width is estimated to be about 40 percent. It is most likely that if the maximum cross section differs greatly from the value stated, it is larger.

The results of Hornboste, Goldsmith and Manley, though not in good agreement, might be altered to give much better agreement if their assumed values for the position of the main resonance and the effective energy of the Cd stopped neutrons were corrected and the existence of the higher resonance levels were considered.

The resonance at 3.7 ev was not well resolved, however it is very probable that the cross section at maximum resonance is greater than 2.2 x 10^{-22} cm^2/atom. The resonance at 9 ev was even more poorly resolved but its cross section at exact resonance is probably greater than 6.7 x 10^{-23} cm^2/atom.

Indium has two stable isotopes, In^{113} and In^{115}, with relative abundance 4.5 and 95.5 respectively. Since three resonances were observed in indium, it is possible to state that at least two of them are in the same isotope. This is the first time that more than one slow neutron resonance has been observed in a single isotope. Since the isotope In^{115} is by far the most abundant, it seems likely that it is this isotope which contains at least two of the resonances, but this is not certain. (Cont'd on next page)

MDDC-272 The Absorption of Slow Neutrons by Indium, by *B. D. McDaniel*, 77 p. (Cont'd from page 155).

The measurement of the width and cross section at exact resonance of the main resonance could be improved somewhat by making observations using a considerably thinner absorber than was used in this experiment. Improved measurements of the weaker resonances could be made by using higher resolution and both thicker and thinner absorbers than the ones which were used in the investigation of those resonances. It is also possible that such measurements might permit better limits to be placed on the scattering cross section.

It is felt that more accurate timing of the arc would improve the apparatus. This improvement might be made by having the timing controlled by the same timing signal that controls the detector channels. The resolution might be improved somewhat by decreasing the length of the chamber. With the present intensity of the neutron source it does not seem feasible to make any further changes to improve the resolution if the effective intensity must at the same time be decreased.

MDDC-273 The Interaction of Nuclear Radiations with Matter, by *R.L. Platzman*, 65 + 30 p.

This report comprises the first portion of what is intended to be a comprehensive monograph on the subject of the interaction of the various nuclear radiations with matter, i.e. on the phenomena associated with the passage of the radiation through a material medium. The specific reaction of the radiation with the nuclei of the medium is not treated. The subject matter is, therefore, concerned with atomic physics rather than nuclear physics.

The present paper deals with only a very small portion of the field implied by the title, principally with the stopping power of matter for heavy, charged elementary particles.

The topics covered include:

Section 1. Classical Theories of Energy Loss
- Early Treatments
- Bohr's Treatment
- Space Distribution of the Energy Loss
- Energy Distribution of the Energy Loss

Section 2. Quantum Theories of Energy Loss
- Old Quantum Theories
- Quantum Mechanical Background
  - Definitions of Various Cross-sections
  - The General Collision Problem
  - The Born Approximation
  - Higher Approximations; Validity of the First Born Approximation
  - Motion of the Atomic Nucleus
- The Method of Bethe
- The Stopping Power of Hydrogen Atoms

(Cont'd on next page)

MDDC-273 The Interaction of Nuclear Radiations with Matter, by *R. L. Platzman*, 65 + 30 p. (Cont'd from page 156).

The Stopping Power of Complex Atoms

Also appendices on:

Conversation of Energy and Momentum in Two-body Collisions
The Two-body Problem with a Coulomb Force
Resume of Various Variables Used To Represent Stopping

Miscellaneous Physical Constants
The Optical and Generalized Oscillator Strengths
Proof of the Summation Theorem for Hydrogen Atoms
Proof of the Summation Theorem in the General Case.

MDDC-274 Project Handbook. Chapter I - Part 1-6. Constants and Conversion Factors, by *R. Platzman*, 12 p.

This paper consists of a series of tables listing the symbols, units of measurements, and various particles used in modern physics and their numerical values.

MDDC-275 Characteristics of Metal Type Electron-Multiplier Tube, by *J.S. Allen*, 12 p.

An electron multiplier tube of the electrostatically focussed type enclosed in a metal shell has been developed. The metal construction permits the use of copper gaskets and the outgassing of the tube by external heating. When a narrow beam of Po alpha-particles hits the first electrode the tube will count every alpha falling upon the sensitive surface. Approximately 5×10^6 electrons reach the final collector for each alpha incident upon the first electrode. The tube may be used as a pulsed detector by varying the potential of one of the electrodes with respect to the others. Both static and dynamic tests were made. A square wave of 150 volts amplitude will turn the tube on and off. A radium source surrounded by 5 cm of Pb was placed near the multiplier tube. The counting rate was about 10^{-4} times the number of photons striking the first electrode.

MDDC-276 The Range of Deuterons in Heavy Water and of Protons in Hydrogen, by *J. Ashkin*, 13 p.

The stopping power of heavy water for deuterons, and the range-energy relation for deuterons in heavy water, have been calculated for deuteron energies from 0 to 750 kv. The range of protons in hydrogen for proton energies from 0 to 1 MV has also been obtained. For proton energies below 60 kv the hydrogen canal ray data of Ruchardt were consulted. Results plotted.

MDDC-277 Distribution Arising from a Point Source of Fast Neutrons Between Two Slowing-Down Media, by *R. Bellman, R. E. Marshak*, 16 p.

The slowing-down problem is treated for a monoenergetic point source located at the interface between two semi-infinite media of different properties. Results tabulated.

MDDC-278 Fluorination of Normal Heptane, by *R. G. Benner, A. F. Benning, F. B. Downing, K. C. Johnson, H. M. Parmelee*, 16 p.

The purpose of this investigation was to develop operating details and design data for manufacture of perfluoro heptane on a large scale was well as to develop suitable control tests and methods of analysis.

Reaction: $C_7H_{16} + 32\ CoF_3 \rightarrow 32\ CoF_2 + C_7F_{16} + 16\ HF + 1000$ K. Cal. (1)

$32\ CoF_2 + 16\ F_2 \rightarrow 32\ CoF_3 + 900$ K. Cal. (2)

The principal reaction is 1 mole of heptane reacting with 33 moles of CoF_3 to give one mole of perfluoro heptane and 16 moles of HF. After a pass of heptane through the reactor the resulting CoF_2 is reconverted to CoF_3 with fluorine.

In operating the reactor, which contained 7 lbs. of cobalt trifluoride, the temperatures of the reactor were adjusted to 225°C. at the inlet end and to 350°C. at the outlet by regulation of the gas burners. The vaporizer was heated to 150°C. and the condenser and receiver cooled to -30 to -40°C.

Liquid normal heptane was fed dropwise from the burette at a rate of about 20 grams per hour into the vaporizer. The heptane vapor entered the reactor through the manifold feed system at these 4 points. For a feed rate of 20 grams per hour the estimated time of contact in the reactor was 2 to 3 minutes. As soon as the organic feed came in contact with the CoF_3, fluorination started as evidenced by a temperature rise in the reactor and it was necessary to decrease the flame on the gas burners to maintain the temperature at 225 to 350°C.

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MDDC-278 Fluorination of Normal Heptane, by *R. G. Benner, A. F. Benning, F. B. Downing, K. C. Johnson, H. N. Parmelee*, 16 p. (Cont'd from page 159).

The exit gases, HF and crude perfluoro heptane, passed through a nickel screen to remove cobalt fluoride dust and then into the condenser. The pressure inside the nickel screen was indicated by this manometer which was a check for plugging of the screen. The product collected in the cold receiver. At the end of the run the reactor was swept with nitrogen to displace fluorocarbon from the reactor into the condenser.

The lower layer of crude fluorocarbon which had a specific gravity of about 1.7 was separated from the upper layer of HF which had a specific gravity of about 1.0. The HF was drowned in ice and water and a small amount of fluorocarbon was recovered by separation from the aqueous layer. The crude fluorocarbon was washed with dilute caustic soda, separated from the aqueous layer and dried. A run of 68 grams of normal heptane gave 212 grams of crude perfluoro heptane and 190 grams of HF, which is equivalent to an 80% yield of fluorocarbon based on complete reaction and an 87% recovery of HF.

MDDC-279 Chemical and Spectrochemical Analysis of Uranium and Plutonium Materials, Manual of Procedures, by *H. E. Boaz, P. Numerof, H. A. Potratz, W. H. Throckmorton*, 40 p.

COLORIMETRIC ESTIMATION OF GOLD IN CYANIDE PLATING BATHS.

By treatment of the solution to be tested with aqua regia, the cyanide is removed and the gold is oxidized. The color intensity of the yellow chlorauric ion serves as a measure of the gold concentration in the solution. Measurements are made against a known standard using a colorimeter. The method is subject to interference by iron or any other impurity which gives color to the solution under the conditions of the test.

MICROVOLUMETRIC ASSAY OF PLUTONIUM (Revised Procedure).

Plutonium as sulfate in 2N H_2SO_4 is reduced to + 3 valence with zinc amalgam under a CO_2 atmosphere and is titrated potentiometrically to + 4 valence with ceric sulfate.

GRAVIMETRIC DETERMINATION OF CARBON AND HYDROGEN IN CALCIUM METAL.

The sample is burned at 1000°C in oxygen diluted with helium and the carbon dioxide and water formed by the oxidation of carbon and hydrogen compounds in the sample are quantitatively absorbed on Ascarite and Dehydrite and weighed. Calcium burns at an uncontrollably fast rate in pure oxygen or in air; by properly diluting the oxygen with the inert gas, helium, the rate of combustion can be easily controlled. (Cont'd on next page)

MDDC-279 Chemical and Spectrochemical Analysis of Uranium and Plutonium Materials, Manual of Procedures, by *H. E. Boaz, P. Numerof, H. A. Potratz, W. H. Throckmorton.* (Cont'd from page 160).

ELECTROLYTIC DETERMINATION OF COBALT IN TUNGSTEN-CARBIDE-COBALT ALLOYS.

The alloy is dissolved in a mixture of hydrofluoric acid and nitric acid. The volatile acids are removed by fuming with sulfuric acid and the residue is dissolved in ammonium hydroxide. Ammonium chloride and sodium bisulfite are added to the solution which is cooled to 10° C and electrolyzed for 45 minutes using a rotating cathode.

FLUORIMETRIC ESTIMATION OF MICROGRAM AMOUNTS OF URANIUM.

The strong greenish fluorescence of uranyl ion in ultraviolet light is used as a measure of its concentration in solution. Cooling to the temperature of dry ice-methanol mixture enhances the fluorescence. The uranium is contained in either concentrated phosphoric or sulfuric acid since they form a clear glass at this temperature. The amount of uranium present is estimated by visual comparison of the intensity of the fluorescence of the sample with that of [illegible] standards.

MDDC-280 The Formation of Uranium Hydride, by *J. E. Burke,* 11 p.

The effect of temperature on the rate of the reaction $2U + 3H_2 \rightarrow 2UH_3$ has been investigated between 150 and 375°C. The hydride forms most rapidly at 225°C. With unpurified tank hydrogen, an incubation period is found during which no apparent reaction occurs. The incubation period can be eliminated by suitably purifying the hydrogen. In eleven runs in highly purified hydrogen, the formula of the product averaged $UH_{3.00}$.

MDDC - 281 A Metastable State of 22 Microseconds in Ta^{181}, by S. De Benedetti, F. K. McGowan. 3p. (See also Physical Review, Vol. 70, p.569, October 1946)

A delayed-coincidence Geiger-Müller counter is described; it is useful in the range 0.000001-0.01 second. The disintegration of Hf^{181} leads to a metastable Ta^{181*}, which decays to the ground state with a half-life of 22 microseconds. The radiation from Hf^{181} consists of a simple β-spectrum of maximum energy about 0.8 Mev, and of 0.5 Mev γ-rays. The delayed radiation, 0.11-Mev electrons, follows the β-radiation. The excitation energy of Ta* is about 0.18 Mev; the number of conversion electrons per disintegration is about 0.6. The transition Ta* $\longrightarrow$ Ta involves a spin change $\frac{1}{2}$ 7/2. No short-lived isomer in other isotopes of spin 7/2 was found in more than 20 other nuclei which were examined.

MDDC - 282 Investigation of Proportional Counters, by B. C. Diven, B. Rossi. 31p.

Experiments on proportional counters with various gas fillings have been carried out with the purpose of determining the gas multiplication as a function of voltage and pressure, and of investigating the uniformity of pulse height for a given primary ionization. It was found that counters can be made to operate satisfactorily with gas multiplications up to several hundred. The pulse height is independent of the distance from the wire at which the primary ionization takes place. No evidence was found for any spread in pulse height being introduced by gas multiplication. The gas multiplication decreases near the end of the wire because of the perturbation of the electric field by the supports at the wire. The normal value for the gas multiplication is only reached at a distance of the order of 10 times the diameter of the support.

MDDC - 283 Electrolytic Cells for Production of Fluorine, by R. C. Downing, et al. 16p. (See also Industrial and Engineering Chemistry, Vol. 39, p.259-262, March 1947.)

A 1500-amp. cell for producing F by electrolysis of KF.2HF was described. Either Ni or C anodes were used. The C anodes gave better current and power efficiency and greater electrolyte economy. The electrodes were insulated from the cover with Teflon (polytetrafluorethylene) which on the side exposed to the action of F contained CaF_2 as filler. With C anodes the potential drop was 8.5 v. with an anode c.d. of 75 amp./sq. ft. For Ni anodes the values were 10-13 v. and 192 amp./sq. ft. For each 1° rise in temperature of the electrolyte, the voltage required decreased by 0.04 v. Current efficiency was above 90%, power efficiency 20-30% for the C anode cell. The Ni-anode unit showed a current efficiency of 70%. Some units were operated for more than 3000 hrs, producing about 2 lb. F per hr. The gas evolved contained 5-15% HF. Freed of HF it analyzed about 98% F.

MDDC - 284 Long Range Alpha Particles Emitted in Connection with Fission — Preliminary Report, by G. Farwell, E. Segre, C. Wiegand. 11p. (See also Physical Review, Vol. 71, p.327-333, March 15, 1947.)

Alphas are emitted in coincidence (i.e., within 5.10^{-6} sec) with fission by U^{235} and Pu^{239}. The maximum range observed (about 23 cm in air.) corresponds to an energy of 16 Mev. About one alpha per 250 fissions is emitted by U^{235} and one alpha per 500 fissions by Pu^{239}.

MDDC - 285 Angular Distribution of Scattering of 30-Kev Neutrons, by D. H. Frisch. 7p.

The ratio of the differential scattering cross section at 45° and 135° for neutrons of approximately 30-Kev energy was studied for various elements. B^{10}, B^{11}, C, and Al give a ratio of unity in the center-of-gravity system within the experimental error, but Au shows some forward scattering.

Element	Mass	Mean angles in center-of-gravity system		$C45^{\circ}/C135^{\circ}$	$\sigma_{\theta_1}/\sigma_{\theta_2}$
		θ_1	θ_2		
B	10	$49^{\circ}03'$	$139^{\circ}03'$	$1.38 \pm .10$	$1.06 \pm .08$
B	11	$48^{\circ}41'$	$138^{\circ}41'$	$1.37 \pm .10$	$1.08 \pm .08$
C	12	$48^{\circ}23'$	$138^{\circ}23'$	$1.20 \pm .06$	$.98 \pm .05$
Al	27	Use approximation for large mass		$1.00 \pm .06$	$.92 \pm .06$
Au	200	"	"	$1.14 \pm .06$	$1.17 \pm .06$

MDDC - 286 Capture Cross Section of Gold as a Function of Neutron Energy, by K. I. Greisen. 14p.

The capture cross section of gold has been measured as a function of neutron energy in the range 30 kv to 3 Mev, by comparing the beta activity induced in a gold foil with the number of fissions in a thin U^{235} or U^{238} sample exposed to the same neutron beam. The results are:

Mean Energy of Neutrons (Kev)	F	R_o	M_{Au} (grams)	σ_r(Au) (barns)
30	1161	202	4.325	1.40
160	1060	143	4.31	0.62
380	1720	162	4.33	0.30
750	2285	131	4.27	0.159
1730	3414	59	4.31	0.088
3000	3322	17	4.275	0.049
200	2048	153	3.09	0.40

F = number of fissions per minute observed in monitor, R_o = initial activity of gold foil, expressed in counts per minute, M_{Au} = mass of gold foil. The data in the last row are from an exposure monitored with a different foil from that used in the other exposures; hence a different thermal calibration was used calculating the last value of σ_r(Au).

MDDC - 287 Theory of Multiplicative Processes. I , by D. Hawkins, S. Ulam. 20p.

General properties of statistics of multiplicative systems are discussed, together with the study of fluctuations in the number of particles in such systems. A general method is indicated through which one may study the case where one takes into account the factors of geometry and time-dependence of constants.

MDDC - 288 Taylor's Hydrodynamics of Strong Shocks Applied to Gases Having Small Values of γ - I, by J. Hirschfelder. 15p.

When γ - 1 is small, the pressure and density gradients become very large at the shock front and very small a short distance behind the shock front. Bethe has made use of this behavior in developing a set of analytical solutions to the hydrodynamical equations which become more nearly valid as γ approaches one. In the second section, direct point-by-point numerical calculations of Taylor's equations are carried out for γ=1.2 and 1.1. From these it may be seen that Bethe's approximate solutions give very good results for values of γ even larger than 1.2.

MDDC - 289 The Role of Instruments In The Atomic Bomb Project, by W. P. Jesse. 11pp. (See also Chemical Engineering News, Vol. 24, p.2906-2909, (November 10, 1946.)

This report describes the important function that instruments played in Hanford plants. The Geiger-Müller counter and its use is described, as are instruments and equipment designed to protect personnel.

Biographical supplement.

MDDC - 290 Solubility of Argon in Uranium, by I. B. Johns. 2p.

A determination has been made of the solubility of argon in uranium. The metal sample, 2.99 g, was converted to powder via the hydride. This powdered metal, after thorough outgassing under high vacuum, was sealed off into a side arm connected to the gas-measuring burette through a break seal. All parts of the apparatus were calibrated so that the displacement of the level in the burette on breaking the break seal could be calculated, assuming no adsorption of gas by the metal. The burette was then filled with argon that had been purified over powdered uranium for 48 hours at approximately 200°C. The apparatus was then sealed off from the vacuum line and argon reservoir so that no stopcocks remained in the system.

On breaking the break seal the level in the burette rose to the expected level within 0.016 ml and remained constant for two hours. On heating the sample to 600°C and cooling again to the original temperature, 23°C, the volume of gas was found to be 0.043 ml greater than at the start, due probably to evolution of gases from the glass walls. The preliminary outgassing had been done at 400°C. The pressure in the system was held constant at 455 mm. At room temperature the amount of argon absorbed by uranium is not greater than 1 part in 300,000 by weight. At 600°C the adsorption is probably less than at room temperature, but is not greater than 1 part in 30,000 by weight if it is of the same order of magnitude as the uncertainties of measurement of the gas volumes at this temperature.

MDDC - 291 Studies Of Adjustments Of A Zinn-Type Ion Source, by T. Jorgensen, Jr. 11p.

This is a report on some work done on the Zinn-type ion source used on the University of Illinois D-D linear accelerator. An arc is drawn between the filament and the anode through the nose. The nose and plate are at ground potential when the arc is running. Ions are drawn from the plasma through its holes in the plate and probe by putting a negative potential of a few kilovolts on the probe.

The filament was heated by means of a transformer and variac. The potential difference across the filament was chosen high enough so that there was good emission from the filament. This potential varied with the nature of the filament. In starting the arc the single-pole double-throw switch was thrown so that an arc was started between the filament and the case (nose and plate). Usually the plasma reached through the nose to the anode under these conditions and the arc continued to run when the switch was opened and the case was floating. The switch was then thrown the other way so the case and filament were at ground potential; the arc continued to run under this condition.

The gas consumption of this type of ion source was measured by a source actually in use on the D-D set. The gas flow was determined by measuring the displacement for a given time of a drop of mercury in a calibrated capillary in the gas line. The pressure of the gas was determined by the gauge on the deuterium supply.

The first measurement was made on the source that had been used for several months. The probe hole had been eroded away to form a conical hole .040" diameter at the end toward the arc and .086" in diameter at the other end. The length of the hole was about .250". The gas consumption when the source was running at a pressure of .03 mm of Hg was 19 cc per hour. This pressure was somewhat lower than that at which the arc was usually run, but the arc ran very well at this pressure.

The second measurement was made on the same source after the elkonite insert in the probe with the conical hole had been replaced with one with a cylindrical hole .040" in diameter. With conditions as nearly the same as before as possible, the gas consumption was 10 cc/hr.

During these measurements the probe potential was set at 5,000 volts but the high potential was not turned on. Data are plotted for various nose spacings (distance between the nose and the plate), various probe spacings (distance between probe and plate), and various diameters of probe and plate holes.

MDDC - 292 Preliminary Determination Of The Neutron Absorption Cross Section Of Long-Lived I^{129}, by S. Katcoff. 6p. (See also Physical Review, Vol. 71, p826, June 1, 1947.)

The slow neutron absorption cross section of long-lived I^{129} was found to be about 8 barns, correct to within a factor of ten. This was done by bombarding, at the Los Alamos water boiler, some iodine which had been isolated from an irradiated uranium slug, then the amount of 12. 6h I^{130} formed was measured.

MDDC - 293 Sweeping Of Radioactive Gases From A Homogeneous Pile, by S. Katcoff. 19p.

The radioactive fission-product gases produced in a homogeneous pile were blown by a stream of air through a long tube along whose axis was a negatively charged wire. The various gases deposited their solid radioactive daughters upon the wire in a manner proportional to their half-lives. By cutting the wire into sections and analyzing each one for several fission products, the following results were obtained:

(1) an approximate half-life of 33 seconds for Kr^{90};

(2) an accurate half-life of 1.7 seconds for Xe^{141}; and

(3) the fraction of each of the fission-product chains containing a gaseous member that was swept out of the water boiler. This is tabulated.

MDDC - 294 The Determination of The Oxygen Content of Metals by the Carbon Monoxide Method, by D. Lipkin, M. L. Perlman. 9p.

Technique and apparatus are described for determining the oxygen content of small samples of metal by vacuum fusion in graphite and by analysis of the gases evolved. The oxide reacts with the graphite at high temperatures, evolving carbon monoxide.

MDDC - 295 Some Neutron Diffusion Problems, by R. E. Marshak. 20p.

This paper contains the solution of some neutron diffusion problems. Section A gives more complete solutions of the slowing-down problem treated in MDDC-277. Section B gives a good approximation to the solution of the problem of the time-decay of the slow neutron intensity (averaged over all space), due to a pulse of fast neutrons. Section C gives a solution of the age equation for a semi-infinite medium with plane source and "black" boundary condition.

MDDC - 296 Hot Wire Reduction Of Metals, (Summary of Literature), by C. R. Maxwell. 9p.

The hot wire method for the preparation of pure metal consists basically of decomposing a volatile compound of the element in question upon the surface of an incandescent body. The method has the advantage over most other methods in that it yields directly a compact metal without the possibility of contamination from a crucible wall.

The incandescent body is usually a refractory wire which is heated by an electric current passing through it. Preferably this wire is drawn from the purest available form of the element being prepared; however, where its properties prohibit drawing, a filament of another non-alloying element may be used. This filament may be removed later by breaking the deposited metal away, or, if it adheres too firmly, by drilling the filament out.

Two general methods of operation are employed. In the first, and probably the most common, the compound being decomposed is formed in the apparatus. Impure metal prepared by another method is placed in the apparatus and the apparatus evacuated and sealed off. A halogen is introduced from an attached liquid air trap, and the apparatus heated to such a temperature that the halogen reacts to form a halide which vaporizes. The halide vapor decomposes to metal and halogen on the hot filament and the halogen reacts with more crude metal, and so forth. In this method relatively small amounts of halogen can deposit large amounts of metal.

The second method is employed for compounds (usually halides) more conveniently prepared in another apparatus. The compound to be decomposed is introduced either as a pure vapor or in a stream of hydrogen. The hydrogen reduces the halide on the surface of the hot filament at a temperature considerably below that required for straight dissociation. However, the rate of deposition by reduction may be considerably different from the rate of deposition by dissociation. In the case of WCl_6 the reduction rate is 100 times smaller than the dissociation rate. The hydrogen is always a potential source of impurities and is itself often dissolved or absorbed in the metal deposit. The excess hydrogen and hydrogen halide or halogen, if straight decomposition is used, are pumped from the apparatus through suitable traps to recover the unreduced or undecomposed halide. An interesting variation is the removal of the halogen by a second metal which forms a halide which is non-volatile at the temperature of the bulb.

Molybdenum, tungsten, columbium, tantalum, and carbon have been prepared from their chlorides. The temperatures for their preparation lie in the range between 1000-1500°C. By the use of the iodides this method has been extended to include B, Be, and all elements of the fourth and fifth groups as well as many neighboring elements. The members of the sixth group cannot be prepared from their iodides because the higher volatile iodides are unstable and the iodides of the type XI_2 and XI_3 are not sufficiently volatile. Only compounds containing four or more halogen atoms or the trihalides of the light elements (BI_3) have sufficient vapor pressure for use in the hot wire method.

The elements on the left side of the periodic table cannot be prepared by the decomposition of the iodides because, first, their iodides are stable and only slightly volatile and, second, the metals are easily vaporized and cannot be heated to a high enough temperature. It may be possible to prepare the rare earths, particularly the last half of the group, in this manner.

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MDDC - 296 Hot Wire Reduction Of Metals, by C. R. Maxwell. 9p. (Cont'd from page 171).

Boron, carbon, and silicon have been prepared by decomposing their hydrides. A serious difficulty is that they do not combine directly with hydrogen to form the hydride. It may be possible to prepare germanium, arsenic, and antimony in a like manner.

A crude metal may be purified by the hot wire method from oxygen, nitrogen, carbon, and the metal compounds and metals which are not attacked by halogens. The former elements remain behind as fine oxide, nitride, carbon, or carbide powder. Many elements are attacked by the halogens, and if they form a volatile halide, may be deposited with the metal. Under certain conditions though, a fractionation may be made. For example, the temperature of the filament may be so high that the impurity vaporizes, as does iron in the preparation of zirconium. Other metals cannot be removed in this manner, as, for example, aluminum. The melting point of the metal is very low, but it forms an alloy with zirconium, which has a high melting point and a low vapor pressure. Aluminum, silicon, boron, and so forth cannot be removed in this manner from zirconium and similar metals. This method serves chiefly for the removal of oxygen, nitrogen, and carbon. To prevent contamination of the deposit by the small amount of oxygen and nitrogen which cannot be evacuated from the apparatus, an auxiliary filament is often used in the bulb. The first metal deposited on this filament will contain those impurties. Deposition is then made on the main filament.

In some cases the hot wire method fails because the iodide attacks the glass or quartz. In attempting to prepare pure Be, an alloy of Be and Si is always obtained.

The following metals may be prepared in a pure form by the use of the hot wire method: Ti, Zr, Hf, Th, V, Cb, Ta, Cr, W, Mo, Cu, Fe, Pt, Rh, C, B, and Re.

A table is given which summarizes the available information on the preparation of metals by this method.

MDDC - 297 Preparation of Boron By Reduction Of BCl_3 With H_2, by C. R. Maxwell. 3p.

A. REDUCTION IN ATOMIC HYDROGEN ARC.

The experiment in which BCl_3 vapor was passed through an arc between tungsten electrodes in a hydrogen atmosphere was performed. The BCl_3 vapor was introduced about 3/8 in. from the arc proper. The target, a thin tungsten sheet held loosely on a larger iron disc, was about one inch from the tips of the electrodes. Less than a gram of boron was deposited on the target in $6\frac{1}{2}$ minutes.

The physical character of the deposit varied with the temperature zone on the target. Crystalline material was deposited in the center (over 1,000°C). A black powder was deposited on the colder edges with a region of vitreous material between the two. More black powder was found behind the target in the box housing the arc.

The heterogeneous nature of the deposit and the large loss of tungsten (35 milligrams per min.) from the electrodes have caused a temporary halt in the study of this type of reduction.

B. REDUCTION ON INCANDESCENT WIRE.

The reduction of BCl_3 vapor with an excess of hydrogen on an incandescent tungsten filament was performed at three temperatures to study the effect of temperature on the rate of deposition and character of the deposit. A H_2/BCl_3 ratio of about 30/1 was obtained by bubbling hydrogen through liquid BCl_3 in a trap immersed in an acetone-dry ice mixture. The entire apparatus was at atmospheric pressure (580 mm), and the rate of hydrogen flow for all runs was 225 cc/min.

C. REDUCTION ON INCANDESCENT GRAPHITE SURFACE.

Boron was deposited by the reduction of BCl_3 with H_2 on the surface of a graphite cylinder heated to 1100°C in a high frequency furnace. It was impossible to heat the one-inch cylinder to a higher temperature in a three-inch induction coil.

MDDC - 298 **Studies In Complex Formation. I. The Extraction Of Ferric Chloride By Isopropyl Ether, by N. H. Nachtrieb, J. G. Conway. 19p.**

It has been established that the empirical formula for the molecular compound extracted by isopropyl ether from aqueous hydrochloric acid solutions of ferric chloride is $HFeCl_4$. About ten molecules of water are found to be associated with this formula weight for extractions carried out from aqueous hydrochloric acid in the range of 2 to 10 molar; it is not known whether this water is essential to the molecular compound.

Evidence is presented for considering the ether-extracted iron complex to be a tetrameric molecule. Since the evidence is based only upon the variation in the partition coefficients of iron and chloride a direct molecular weight determination is required. Conformity of the absorption spectrum of the ether-extracted complex with Beer's Law indicates that a single species of molecule is formed.

MDDC - 299 **Fast-Neutron Distribution: Two Infinite Plane Slowing-Down Media With Point Source In One Medium, by E. Ostrow. 15p.**

This paper treats a generalization of the problem discussed in MDDC-277. The source of neutrons, instead of being on the interface between the two semi-infinite plane media, as in MDDC-277, is now assumed to be in one medium at an arbitrary distance from the interface. The general solution is derived with the use of the Laplace transform technique.

MDDC - 300 Fluorination Of Hexafluoroxylene, by H. M. Parmelee, et al. 17p.

The hexafluoroxylene in the vapor phase was passed over finely divided cobalt trifluoride at 300°—350° in a reactor. The reactor is a horizontal steel cylinder, 12" x 4'6". An agitator shaft, with plows attached at intervals along it, traversed the cylinder lengthwise. The reactor was heated and cooled by circulated air.

The reactor was charged with 85 lbs. of finely divided cobalt difluoride and the mass heated to 250°—275°. Fluorine was fed from the generators at 0.5 to 1.5 lbs. per hour through the first port on the manifold. The heat of reaction raised the temperature to about 350°C. When fluorine was detected in the exit gas, the fluorine was shut off and the reactor swept with nitrogen. The sweeping cooled the reactor considerably, so it was heated again to 290°—300°. Hexafluoroxylene was then fed into the vaporizer at 15 cc per minute. The vapors passed through the ports into the reactor, where reaction took place, causing a rise in temperature. The reactor temperature was controlled at 300°—345°. During the reaction the temperature peak moved slowly down the reactor. The products, consisting of fluorocarbons and hydrogen fluoride passed through the dust screen and were condensed in the condenser. At the end of the feed the reactor was swept with hydrogen fluoride to push the last of the fluorocarbon vapors into the condenser. The liquid products were collected in the receiver where they separated into two layers. The heavy fluorocarbon layer (specific gravity over 1.8) was separated from the light hydrogen fluoride layer (specific gravity of $< 1.$) by drawing the lower layer off into 5% sodium hydroxide solution to wash out the dissolved acid. The product was dried over calcium chloride.

A normal charge of 8.9 lbs. (2872 cc) of hexafluoroxylene gave 15.1 lbs. of fluorocarbon, or 91% of theory. The recovery of hydrogen fluoride was 80% of theory and the cobalt trifluoride was about 70% exhausted. It was regenerated with fluorine. When the crude fluorocarbons were repassed through the reactor at 45-50 cc. per minute, very little hydrogen fluoride was given off and the weight yield was 98%.

Hexafluoromonochlorodimethyl cyclohexane was fluorinated in the same manner as was hexafluoroxylene and gave similar results, with about three-fourths of the chlorine being replaced with hydrogen. The corresponding dichloro compound gave a mixture containing considerable amounts of incompletely reacted material.

MDDC - 301 Range of U^{235} Fission Fragments in Photographic Emulsion, by H. T. Richards. 7p.

Eastman's fine grain emulsion 548-0 has been found suitable for recording fission fragments while remaining completely insensitive to alpha-particles. The high background grain count of this emulsion was removed by Liebermann and Barschall's technique and the plates then impregnated with uranyl salts. One set of plates was used as a control and the other exposed to slow neutrons. The plates were then developed and examined under dark field illumination. N tracks were observed on the control plates. Four hundred tracks on the exposed plates were measured, and the range distribution is in agreement with ionization chamber measurements of total energy distribution reported by other workers. No larger angle scatterings were observed for the portion of the range to which the emulsion is sensitive. No ternary fissions were observed. The measured range distribution showed a sharp maximum at 23 microns and extended from 11 to 33 microns.

MDDC - 302 The Production Of Slow Neutrons In A Carbon Block, by C. Richman, T. Snyder, R. W. Williams. 29p.

The problem of using a graphite block in conjunction with a source of fast neutrons to obtain a source of nearly pure thermal neutrons has been investigated both theoretically and experimentally. Calculations of the neutron flux density in the block as a function of energy and position when a parallel beam of neutrons of 6 and 3 Mev are incident on one face show the depth of block required for a given purity of thermals. The width of block desirable is shown to be > 200 cm.

Neutrons of maximum energy 13 Mev from a cyclotron surrounded by water tanks were used, and a flux ratio of thermal to indium resonance neutrons of 2×10^4 with a thermal flux of 3.6×10^5 was measured by the indium foil technique in a block of cross section 7' x ~5'6" at a depth of 6'. The fluxes of neutrons of 1.44 volts and thermal energies are given for four different block arrangements as a function of depth in the block. These curves show that the large value of $(nv)_{th}/(Nv)_{In}$ obtained arises from the large number of slow neutrons incident upon it. From the relaxation distance of the quantity $(Nv)_{In}$ observed deep in the block, one finds that the mean free path of neutrons of ~13 Mev in graphite is 16 cm.

MDDC - 303 Model 100 Preamp Circuit Schematic, by M. Sands. 1 fig.

Circuit diagram of instrument.

MDDC - 304 A Modified Procedure for the Quantitative Determination of the Urinary Coproporphyrin Isomers (I and III), by S. Schwartz, S. Cohen, C. J. Watson. 21p.

A new procedure is described for the microquantification of the coproporphyrin isomers I and III. It is based on fluorescence quenching of their esters in aqueous solution. This quenching has been shown to be due to coprecipitation of the two isomers.

The isomer distribution in two to five micrograms total prophyrin is analyzed in this procedure. If necessary, the method may be adapted to the analysis of much smaller samples.

An average error of less than 3 per cent was obtained in over one hundred recovery studies.

MDDC - 305 Element 94 In Nature, by G. T. Seaborg, M. L. Perlman. 7p.

A chemical method for separating and concentrating elements 94 or 93 from uranium and thorium has been applied to samples of pitchblende concentrates from the Great Bear Lake region of Canada. These samples of 94 and 93 precipitated with rare earth carrier have been counted for fissions with slow and with fast neutrons, and an upper limit of 1 part in 10^8 to 10^9 has been set for the amount of these elements in the sample. Based on the number of alpha counts in the sample, 1 part in 10^{14} is estimated as the amount of the 30,000y 94^{238} in the original pitchblende concentrate.

MDDC - 306 Piling Up Of Counts, by R. Serber. 5p.

The question of piling up of background counts in an ionization chamber has arisen so often that an estimate of the probability of such occurrences, even though on the basis of a very simple approximation, is made. This approximation is that a count is recorded whenever the total ionization occurring during a resolving time τ is greater than a certain bias energy E_B.

If N be the number of charged particles produced in the chamber per second, then $n = N\tau$ is the number expected during a resolving time, and the frequency of getting n particles within one resolving time is

$$p_n = Ne^{-\bar{n}} \frac{\bar{n}^{n-1}}{(n-1)!} \qquad (1)$$

To obtain the counting rate (1) must be multiplied by the probability that n particles produce an ionization greater than E_B and a sum taken over all values of n.

Two cases are considered. The first is that the energy of the charged particles is uniformly distributed between zero and E_{max}; this would be the situation for monoenergetic neutrons of energy E_{max} falling on a hydrogen-filled chamber.

The second case is that the charged particles have an energy distribution increasing linearly with decreasing energy below E_{max}. This approximately represents the situation for neutrons falling on a paraffin-lined chamber, or for α particles coming from the walls.

MDDC - 307 Absorption Curve and Energy Of 31 Sec. O^{19} β-Rays And Cross Section, by L. Seren, W. E. Moyer, W. Sturm. 3p. (See also Physical Review, Vol. 70, p.561, December 1946)

Measurements were made on the absorption of O^{19} β rays by irradiating distilled water in the Argonne pile. Aluminum absorbers up to .875 gms/cm^2 were used and one point was taken with 1.84 gms/cm^2 Pb absorber. From the absorption curve the range can be estimated as 1.4 gms/cm^2 Al which corresponds to approximately 3 Mev β rays. A further check on the energy is obtained by comparing the mass absorption coefficients with Al^{28} and K^{41} β rays which have been measured in the same geometry.

31 sec O^{19} μ = 2.56 cm^2/gm Al
2.4 min Al^{28} μ=2.5 cm^2/gm Al 3.3 Mev β's cloud chamber measurement
12.4 hr K^{41} μ =2.56 cm^2/gm Al 3.5 Mev β's cloud chamber measurement

From the range and absorption coefficients, it would seem reasonable to conclude that the energy of the O^{19} β rays is about 3.3 Mev. Gamma rays also accompany the 31 sec activity, as shown by the point on the absorption curve taken with the Pb absorber.

In addition to the 31 sec β rays, a half-life of $\approx$4 min was observed; probably due to an impurity in the water. The saturation value of the 4 min activity was $\approx$25% of the 31 sec activity.

John Marshall has measured the cross section of O^{18} assuming that O^{19} β rays had the same absorption coefficient as UX_{II} β rays. On the same geometry that authors used to measure the absorption coefficient of O^{19} β rays they obtained=4.88 cm^2/gm for UX_{II} β rays. Hence Marshall's value of 3.5 x 10^{-28}cm^2 is high because he assumed O^{19} β rays to be less penetrating than they actually are. A correction can be made as follows: Counter wall used in Marshall's measurements is .050 gms/cm^2 Al; thickness of water layer used was $\approx$ 3mm=.300 gms/cm^2. One-half of the water layer is the effective self-absorption thickness. Hence the β ray absorption correction factor ϵ-(4.88-2.56) (.050 + .150) = ϵ-(2.32) (.200) = .63 which reduces the cross section of O^{18} to 2.2 x 10^{-28}cm^2 and the average cross section per oxygen atom is thus 4 x 10^{-7} x 10^{-24}cm^2 for normal oxygen.

MDDC - 308 An Intense Positive Ion Source For Solids, by A. E. Shaw. 13p.

A positive ion source for solids has been developed. A tungsten crucible containing the solid material and heated by electron bombardment produced intense beams of singly charged ions. Pt-Ir (15%) yielded 120 μA., for 100 watts of electron power; La_2O_3 yielded 212 μA., for 105 watts, and Sm_2O_3 yielded 40 μA. for 150 watts. A mass spectrographic analysis of the positive ions from the tungsten crucible containing La_2O_3 and UN revealed the presence of La^+, LaO^+, W^+, WO^+, U^+, UN^+, and possibly UO_2^+. A similar analysis of the ions from Pt-Ir (15%) revealed the presence of all the singly charged isotopes of W, Pt, and Ir. It is anticipated that this source will find application in the mass deposition of isotopes. For example, in 10 minutes a deposit of 0.11 micrograms of the completely resolved isotopes of samarium has been obtained.

MDDC - 309 Tables For Conversion Of Atomic Weight And Volume Percentages In Alloys Of Heavy Metals, by C. S. Smith. 8p.

Tables have been compiled and are given to facilitate prompt and accurate conversion of atomic and weight percentages in systems involving elements of widely differing atomic weights.

Use of these tables depends on the following rearrangement of the common conversion formulae:

$$\frac{x}{100-x} = \frac{A}{B} \quad \frac{y}{(100-y)}$$

where x and y are the weight and atomic percentages, respectively, of the element of atomic weight A in a binary alloy with elements of atomic weight B. Tables I and II give values of the function $\log \left[x/(100-x)\right]$, and Tables III and IV, values of log (A/B) for various common combinations of elements.

The tables are used in exactly the same manner as ordinary log tables. To convert from a certain weight percentage to atomic percent, the value of $\log \left[x/(100-x)\right]$, corresponding to the known weight percentage, is first read from Table I or II. From this value is subtracted the appropriate log atomic weight ratio from Tables III or IV, giving a resultant value of $\log \left[y/(100-y)\right]$, corresponding to the atomic percentage directly read from Table I or II. Conversions in the reverse direction, i.e., from atomic to weight percentages, are done by adding the log (A/B) value.

Tables are equally good for conversions to or from volume percentages.

MDDC - 310 A Spectrographic Method For The Determination Of Fluorine, by R. W. Spence. 6p.

Fluorine distilled off as SiF_4 is dissolved and evaporated on an electrode for spectrographic determination. Determination of 1% of F has been attained and further improvement is anticipated.

MDDC - 311 Report on an Investigation of the Behavior of Argon-Hydrogen Mixture and Isobutane In a Spherical Chamber, by H. Staub, D. Nicodemus. 7p.

A short investigation was made on the collection of + and - ions in a spherical chamber filled with argon-hydrogen and isobutane to obtain some information about the distribution in the size of pulses produced by monoenergetic d's in a very inhomogeneous field. The dimensions of the chamber were R_i = 1 cm, R_o = 4cm; the outer electrode was connected to a negative potential up to 5000 volt, the inner one to a conventional preamplifier and amplifier. Number and size of the pulses were recorded by a differential selector, whose bias was linearly related to the input voltage of the amplifier. The time constant of the amplifier could be varied from $7x10^{-5}$ sec to $1.4x10^{-2}$ sec. A source of RaE in equilibrium with Po was placed inside the chamber on the inner or outer electrode.

Results: 1. Isobutane at 2.25 atm absolute: Range of α's 0.57 cm. (a) Source on outside electrode. Pulses extremely small. They show, however, only slight dependence on time constant of amplifier. With 4000 volts and $\tau = 7x10^{-5}$sec a curve was obtained. The endpoint corresponds to 9% of the expected maximum pulse size. Apparently these pulses are due to collection of a small fraction of free electrons. (b) Source on inside electrode: Pulses considerably larger at 3000 volts with $\tau = 7x10^{-5}$ sec. Endpoint corresponds to 25% of expected maximum. This shows that the much higher field at the inner electrode more than offsets the loss which one would expect due to the fact that the ionization occurs in this case much closer to the positive electrode.

2. Isobutane at 1.6 atm absolute: Curves which were obtained show the dependence on voltage and time constant for the two cases of the source being on the inner or outer electrode. A strong dependence of the pulse size on the voltage

(Cont'd on next page)

MDDC - 311 Report on an Investigation of the Behavior of Argon-Hydrogen Mixture and Isobutane in a Spherical Chamber, by H. Staub, D. Nicodemus. 7p. (cont'd from page 181).

is noticeable, whereas variation of the time constant is much less effective. This again seems to indicate that recombination may be one of the main causes for the smallness of the pulses.

3. 5 atm argon and 2 atm H_2 at 4000 volts, $\tau = 1.4 \times 10^{-2}$ sec. α- source outside. Range of particles 0.74 cm. Although this represents the highest possible τ and the highest voltage at the lowest reasonably possible stopping power and efficiency a sharp α-line was not obtained. Probably no free electrons were collected and thus the field at the outer electrode was simply too small to insure a short enough collection time. The maximum pulse length corresponds to about 47% of the expected maximum.

4. The total capacity of the input (including preamplifier which amounts to about 15 $\mu\mu$F) was determined to be 27.4 $\mu\mu$F. The partial capacity between outer and inner electrode was 3.3 $\mu\mu$F.

MDDC - 312 (pn) Reactions in Deuterium, Scandium, and Vanadium, by R. F. Taschek. 12p.

The thick target yield curves for D(pn) 2p, Sc(pn)Ti, V(pn)Cr have been investigated to determine whether the yields are large enough to make these reactions useable neutron sources. The first reaction should give a collimated neutron beam, and the latter two reactions should give neutrons of very low energy and high symmetry so far as momentum considerations are concerned. The yield from D(pn)2p appears to be too small at threshold for practical use; Sc(pn)Ti and V(pn)Cr give enough neutrons near threshold to make them appear promising as sources of low energy neutrons.

MDDC - 313 The Analysis and Disposal of Fluorine, by S. G. Turnbull, et al. 11p. (See also Industrial and Engineering Chemistry, Vol. 39, p.286-288, March 1947)

A safe analytical method for industrial control of high-quality F has been developed. This method is based on the reaction of HF with NaF, the conversion of F to Cl by reaction with NaCl, and analysis of the Cl for O and inert gases by standard procedures. The overall error in F purity by this method is less than 0.4%. A vapor-pressure method for determining the HF content is described. It involves separating the HF by fractional distillation. For gas mixtures containing less than 10% F, the F can be determined by its reaction with dilute HI solutions. The main equation is $F_2 + 2HI \rightarrow 2HF + I_2$. A safe method for the disposal of waste F on a large scale has been developed and satisfactorily operated. The waste F is burned with hydrocarbon gases, such as butane or propane, and acid products (HF) are removed from nontoxic C fluorides by scrubbing with water and NaOH. A 4-inch ring burner disposes of 4.5 lb F per hour.

MDDC - 314 Turner Vacuum Valve, by C. M. Turner. 2p.

Drawings of valve.

MDDC - 315 Photo-Neutron Sources and The Energy of the Photo-Neutrons, by A. Wattenberg. 26p. (See also Physical Review, Vol. 71, p.497-507, April 15, 1947.)

In a preliminary study photo-neutrons were observed to be produced by the γ-rays from Na^{24}, Mn^{56}, Ga^{72}, As^{76}, and La^{140} when these artifically radioactive isotopes were placed in D_2O or Be; F^{20}, Al^{28}, Cl^{38}, In^{116}, and Sb^{124} produced neutrons only in Be. The first group of isotopes must have γ-rays with energy higher than 2.18 Mev, and the second group must have γ-rays greater than 1.63 Mev but less than 2.18 Mev. No photo-neutrons were observed from Co^{60}, Cu^{64}, Ag (225 day 1/2 life), Pr^{142}, Eu^{151}, Dy^{165}, Ta^{182}, Re^{188}, Ir (19 hour 1/2 life), and Au^{198} in Be; the intense γ-rays from these isotopes must have energies less than 1.63 Mev. In a second experiment the energy of the photo-neutrons from nine of these sources was determined by measuring the hydrogen scattering cross section of the emitted neutrons. Seven of the sources seem to emit homogeneous groups of neutrons; they are: Sb+Be, Ga + D_2O, La + D_2O, Mn + D_2O, Na + D_2O, La + Be with neutron energies .024, .13, .13, .22, .22, .62, and .83 Mev, respectively, for the particular sized sources studied. Mn + Be emits three groups of neutrons of different energies, but more than 80% of the neutrons of these energies are: for Na^{24}, 2.74 Mev; for Mn^{56}, 1.81 and 2.7 Mev (a third γ-ray is present); for Ga^{72}, 2.50 Mev (at least one other γ-ray is present with an energy between 2.2 and 1.63 Mev); for Sb^{124}, 1.67 Mev; and for La^{140}, 2.49 Mev. The total neutron cross section of carbon is also given for seven of these photo-neutron sources.

MDDC - 316 Safety Circuit with DC Amplifier, by R. J. Watts. 15p.

A method is described to record the rise in intensity of any hard β, γ, or neutron radiation and to cut off the radiation at any predetermined level. A range in intensity of a factor of one million may be covered easily. The equipment is designed so that if any part fails it will fail safely, i.e., in such a manner as to cut off the radiation. The electronic circuits are readily adaptable to many uses and have been used to monitor a cyclotron. Any current of 10^{-11} amperes or higher from a high-impedance source will operate the mechanism.

MDDC - 317 Fission Products: 25 — Minute Samarium 155, by L. Winsberg. 14p.

Extraction of Sm from irradiated uranium and plutonium has revealed the presence of a short-lived Sm isotope in fission with the following characteristics—half-life, 25 $\pm$ 2 minutes; β range of ~880 mg Al/cm^2 corresponding to an energy of 1.9 Mev; γ radiations with half-thickness in Pb of ~2 gm Pb/cm^2 (0.3 Mev); and a fission yield in U^{235} of 0.031% and in Pu^{239}, 0.21%.

MDDC - 318 Study of Emulsions for Photographing Oscilloscope Screens, by N. York. 3p.

1. Speeds of unaltered films. The fast panchromatic films are faster than the ortho films but can be used only where the shutter is open a fourth of a second or less. On longer exposures the panchromatic emulsions are fogged by the red light from the heating elements in the tubes.

2. Preheating. Exposures were made while the emulsions were hot. It was found that the highest practical temperature for heating films prior to exposure is in the range 65° to 70° C. At higher temperatures the films tend to buckle and char. Emulsions kept at 65°C for one-half hour show no fog on development but longer times or higher temperatures produce fog. At this temperature all emulsions gained approximately 10 per cent in speed with the exception of Super Panchro Press Sports type, which decreased in speed by 30 per cent. The reason for this decrease has not been determined.

3. Prefogging. Prefogging the emulsions to a density of 0.3 to 0.4 with the light from an ordinary tungsten lamp gave a speed increase of the order of 50 per cent, except Ansco Fluorapid Blue, which is apparently slightly prefogged when received. When fogged to the same density, Fluorapid Blue and SSS-Ortho have the same speed. Prefogging to densities higher than 0.3 does not increase the speed any appreciable amount and results in a less pleasing negative.

4. Hypersensitization. No conclusive advantageous results have been attained in attempts to hypersensitize emulsions.

5. Combined methods. Combinations of methods give additive effects only slightly less than if each were independent.

For green screens the best film emulsion is Super Panchro Press Sports Type, untreated, with a speed of 5"/microsecond at 6-kv potential. Properties of Ansco, Ilford, and Eastman films are tabulated.

MDDC - 319 Early Fluorocarbon Studies At Columbia University, by G. H. Cady, L. L. Burger, E. J. Barber. 71p. (See also Industrial and Engineering Chemistry, Vol. 39, p290-292, March 1947)

A technique for catalytic fluorination is given which makes possible the production of desired saturated fluorocarbons in yields up to 87% by the reaction of the corresponding hydrocarbon with F. The hydrocarbon vapor and F are diluted with about 2 volumes of N and are gradually mixed at 140° to 325° (optimum, 200°) in an electrically heated reactor (5 ft. long and 3 in. and about 1 in. in diameter at inlet and outlet, respectively), which is filled with fine Cu turnings or ribbon coated with a thin layer of Ag fluorides. A slight excess of F is used so that the proportion of partially fluorinated compounds in the product is small. At temperatures below 140° the surface of the catalyst becomes coated with a film of polymerized fluorocarbon and loses its activity. The material fluorinated, average temperature of reaction, product, and yield, respectively, for typical examples of catalytic fluorination are: C_6H_6, 265°, C_6F_{12}, 58; heptane, 135°, C_7F_{16}, 62; $PhCF_3$, 200°, C_7F_{14}, 85; $C_6H_4(CF_3)_2$, 200°, C_8F_{16}, 87; anthracene, 300°, $C_{14}H_{24}$, 43. Light hydrocarbon lubricating oils of naphthenic, aromatic, and paraffinic base yield products of wide boiling range, including 12-19% yields of fluorocarbons corresponding in number of C atoms per molecule to the original materials. It appears probable that the fluorocarbons are produced by the action of the fluorinating agent, AgF_2, upon the hydrocarbon vapor. The catalytic method is preferred to the method using CoF_3 for producing lubricating oils but not for producing fluorocarbons of moderate molecular weight such as C_7F_{16}.

MDDC - 320 Neutron Physics, by E. Fermi. 75p. (Revised version released August 27, 1946)

This paper comprises notes taken at a series of lectures given by Professor Fermi at Los Alamos. The main subjects are as follows:

I. NEUTRON SOURCES
- (1) (α,n) Reactions
- (2) Photo Sources, (γ,n)
- (3) Artificial Neutron Sources

II. COLLISIONS OF NEUTRONS WITH NUCLEI
- (1) Neutron Cross-sections as a Function of Energy
- (2) The Measurement of Total Cross-section
- (3) The General Features of Collisions
- (4) Applying this Result to Several Situations
- (5) Some Examples of the Foregoing Reaction Types

III. THE CHART OF STABLE ISOTOPES AND WHAT IT IMPLIES ABOUT NUCLEAR REACTIONS INVOLVING NEUTRONS
- (1) The Segre Isotope Chart
- (2) Isotope Weights and (n,γ) Reactions

IV. MODELS OF NUCLEI AND OF NUCLEAR REACTIONS
- (1) The Compound Nucleus
- (2) Neutron Resonances and Spacing of Nuclear Levels
- (3) Two Models of the Nucleus

V. THE SCATTERING OF NEUTRONS
- (1) The Breit-Wigner Formula
- (2) Some General Considerations on the Scattering of Neutrons
- (3) Scattering by a Potential
- (4) The Scattering of Neutrons by Crystals

(Cont'd on next page)

MDDC - 320 Neutron Physics, by E. Fermi. 75p. (Revised version released August 27, 1946) (Con't. from page 186).

VI. THE SLOWING DOWN OF NEUTRONS
- (1) The Change of Direction and Energy upon Collision
- (2) Distribution of Neutrons from a Point Source - Experimental Methods
- (3) Distribution of Neutrons from a Point Source - The Calculation of $\overline{r^2}$
- (4) Distribution of Neutrons from a Point Source - The Age Equation

VII. THE DISTRIBUTION OF SLOW NEUTRONS IN A MEDIUM
- (1) The Differential Equation for Slow Neutrons
- (2) The Boundary Conditions for the Differential Equation
- (3) The Diffusion Length
- (4) The Albedo, or the Reflection Properties of a Bounding Surface for Neutrons

VIII. NUCLEAR FISSION
- (1) The Binding Energies of Nuclei
- (2) The Fission Process
- (3) The Particles of Fission

MDDC - 321 Analytical Methods (Chapter II - Pharmacology and Toxicology of Uranium Compounds) by J. F. Flagg. 75p.

Five methods are given for determining semimicro or micro quantities of uranium in biological samples: a colorimetric method, a fluorophotometric method, a polarographic method, a semimicro volumetric method, and a spectrochemical method. In the last named, the uranium is extracted with ether and determined spectrographically with a sensitivity of 0.1-1.0 micrograms per gram and a standard error of less than $\pm$ 20%.

Procedures are also detailed for the analysis of microgram quantities of fluorine. These include thorium nitrate titration methods, an enzymatic method, a polarographic method, and a direct bleaching method using ferric salicylate.

MDDC - 322 Introduction, (To The Pharmacology And Toxicology Of Uranium Compounds), by H. C. Hodge.34p.

A comprehensive description of the organization and allocation of responsibilities and function is given of the University of Rochester Project which performed research in the Pharmacology and Toxicology of Uranium Compounds.

The following subjects are treated:
Historical
Importance of Inhalation of Dust
Toxicology Program
Personnel
Collaborating Divisions from the Manhattan Department of the University of Rochester
The Usefulness of Animal Experimentation in the Control of Uranium Poisoning
1. How Toxic is a Compound?
2. What are the Acute Toxic Effects?
3. Chronic Toxic Effects
4. Factors Influencing Toxicity
5. The Mechanism of Toxic Effects
6. Early Detection of Poisoning
7. Restriction of Survey Studies on Humans
8. Prophylaxis
9. Treatment of Uranium Poisoning
10. Medical Supervision
11. Maximum Allowable Concentration

Security Regulations

MDDC - 323 Summary, (Summary Chapter Of The Pharmacology And Toxicology Of Uranium Compounds), by H. C. Hodge. 70p.

This report presents a summary of the work performed at the University of Rochester on the Pharmacology and Toxicology of Uranium Compounds.

Detailed comprehensive summaries are given for the following subjects:

PART I.

1. Chemistry of Uranium Compounds
2. Analytical Methods
3. Statistical Methods
4. Pathological Anatomy of Uranium Poisoning
5. Characteristics of Uranium Poisoning
6. Toxicity Following the Parenteral Administration of Certain Soluble Uranium Compounds
7. Studies of the Toxicity of Various Uranium Compounds
8. The Toxicology of Compounds of Uranium Following Application to the Skin
9. The Toxicology of Compounds of Uranium Following Application to the Eye
10. Toxicity Following Inhalation
11. Distribution and Excretion of Uranium
12. Tolerance to Uranium Poisoning
13. The Action of Uranium on Enzymes and Proteins
14. Catalasuria as a Sensitive Test for Uranium Poisoning
15. The Mechanism of Action of Uranium Compounds in the Animal Body
16. Studies in Human Exposures to Uranium Compounds

PART II. FLUORIDES

PART III. SPECIAL MATERIALS

1. Boron Compounds
2. Fluoro-Carbons
3. Respiratory Protective Devices

MDDC - 324 Flow Diagrams, Pictures of the Plant and Equipment used in the Production of Fluorine, Fluorolube, Hexafluoroxylene, and Chlorohexafluoroxylenes, by Hooker Electrochemical Company. 43p.

MDDC - 325 Fluorination Of Petroleum Oils (I) Reaction In The Vapor Phase With Cobalt Trifluoride, by C. F. Irwin, et al. 11p. (See also Industrial and Engineering Chemistry. Vol. 39, p.350-352, March 1947)

The vapor phase fluorination of hydrocarbons with CoF_3 was extended to the higher boiling oils, such as kerosene, and light lubricating oils in order to obtain fluorocarbons with a boiling range of 180-350°C /760 mm. The lower boiling fluorocarbons were desired as a medium for fluorination reactions and the heavier ones for other purposes.

The reactions involved in the preparation of fluorocarbons by the method are:

1. $2CoF_2 + F_2 \xrightarrow{200\text{-}300^\circ} 2CoF_3$

2. $4nCoF_3 + \text{-}(CH_2)n\text{-} \xrightarrow{275\text{-}350^\circ} \text{-}(CF_2)n\text{-} + 4nCoF_2 + 2nHF$

At the temperatures used the replacement of hydrogen by fluorine was fairly complete but the yields were seldom above 80% due to "cracking." The hydrocarbon oil was vaporized in a stream of HF or N and passed over 100 pounds CoF_3 at 300-350°. A contact time of about 3 minutes and utilization of about 50% of the CoF_3 gave optimum yield (about 34%) of fluorocarbon oils. Retreatment of first-pass products with fresh CoF_3 (made by regeneration of the reduced reagent with F) or with AgF_2 (see MDDC - 331 below) was necessary to reduce its H content below 0.05%.

MDDC - 326 Is There An "Indirect" Effect Of Radiation, by J. S. Lawrence, W. N. Valentine, A. H. Dowdy. 35p.

1. The general aim of the investigations here reported has been to obtain evidence for or against "indirect" radiation effects.
2. To this end, twenty-six successful cross circulation experiments (carotid to carotid anastomoses) have been performed between normal cats and radiated cats.
3. Cross circulation was established in most instances at some specified time interval after the radiation of one partner. All intervals up to eighty-two hours after radiation of one partner were covered.
4. In seven experiments cross circulation was established and then one animal radiated while the other was shielded. These were considered the most critical experiments of the group.
5. Detailed data on leukocyte and lymphocyte counts in the normal animal obtained during an approximately twenty-eight day period of follow-up are presented.
6. These data are not considered to support the thesis of indirect effects peculiar to radiation. A trend toward slightly lowered absolute lymphocyte counts in normal animals after cross circulation was not considered significant, and in no instance did leukopenia develop in the normal animal.
7. The literature is reviewed and discussed.

MDDC - 327 A Bent Crystal Neutron Spectrometer And The Cross Sections Of Cadmium And Iridium, by R. B. Sawyer, E. O. Wollan, K. C. Peterson, S. Bernstein. 17p. (See also Physical Review, Vol. 72, p. 109-115, July 15, 1947.)

In many experiments it is desirable to use a beam of monoenergetic neutrons of low energy. With the advent of the uranium pile as a research tool, furnishing a high neutron flux, one of the simplest and most satisfactory methods of securing an approximately monoenergetic beam of slow neutrons is by Bragg reflection from a crystal. Although the useable energy range is not great, there are a number of phenomena in this region which are worth investigation. Among these are the total cross sections of materials for slow neutron bombardment. This paper describes a neutron spectrometer similar to the Cauchois transmission type of X-ray spectrometer and its application to the measurement of the total cross sections of cadmium and iridium. The instrument gives good resolution of neutron resonance peaks of about 0.1 ev width at half maximum at energies up to 1 ev. A diagram of spectrometer focussing conditions, horizontal and vertical sections of the spectrometer, and cadmium and iridium cross-section curves are included.

MDDC - 328 A Study Of The Electrolytic Generation Of Fluorine, by W. C. Schumb. 36p. (See also Industrial and Engineering Chemistry, Vol. 39, p.244-248, March 1947)

The most favorable conditions for the generation of F were found to be electrolysis of a fused salt bath with KF. 1.8-2.0 HF as the electrolyte at 100° with carbon anodes. For the control of the HF content of electrolyte employed in the generation of fluorine, which should be kept within rather narrow limits if polarization of carbon anodes is to be avoided, a specific gravity method was developed, in which a monel float was used to indicate the composition at the observed temperature of the electrolyte. Adjustment of the float to an equilibrium position was carried out by addition of small weights to a forked stylus attached to the body of the float. The specific gravities of electrolyte mixtures ranging in composition from KF.1.76 HF to KF.1.90 HF, at 85° to 100°C were determined by a copper pycnometer. Measurements of the specific conductance of electrolyte mixtures were carried out in a specially designed cell, made of Saran, at 90 to 100°C, over the range 37 to 45 per cent HF. Reproducible results were obtained only when the platinum disc electrodes were scoured prior to each refilling of the cell with electrolyte.

The importance of providing circulation of the electrolyte vertically around the cathode during electrolysis was demonstrated by comparative experiments with two cells, in one of which such circulation was prevented, in the other, permitted. Cooler operating temperatures were attained when such circulation was provided, and as a result larger current densities could be employed without giving rise to polarization difficulties. In the course of these experiments it was noted that cathode polarization appeared to result from the development of a bi-polar condition of metal parts interposed between anode and cathode, especially the solid diaphragm skirt. A somewhat detailed study was made of this phenomenon.

Addition of lithium fluoride as an aid in preventing polarization of carbon anodes is complicated by the fact that the solubility of the LiF in the electrolyte is quite small, and on prolonged use of the cell nearly all of the added fluoride is found to settle to the bottom of the cell with the sludge. Similar results were noted with added aluminum fluoride. The precise role of such addition agents in preventing polarization troubles is not known definitely, and their true solubility in the electrolyte has not been determined accurately.

MDDC - 329 Acute Toxicity of Inhaled 275-Day Ce^{144}, by H. C. Seibert, R. Abrams. 27p.

In an attempt to estimate the acute toxicity of insoluble, radioactive material in the lungs, rats were exposed to smokes containing 275-day Ce^{144}. Groups of 200 g rats received the following doses: 3.2, 14, 39, 50, and 200 μc/rat. Weight loss was significant only in those exposed to 200 μc. These had a median survival time of 39 days and were all dead within 120 days. The 39 μc rats had a median survival time of 282 days, while 90 per cent of the 14μc animals were still alive after 300 days.

As had been demonstrated in tracer experiments, absorption from the lung was slow, and liver and skeleton were the primary sites of deposition of the absorbed material. It was not possible to show any definite effect of dose on distribution. Radiation doses to the various tissues were calculated, but, in general, it was not possible to correlate death with the dose to any single tissue.

Preliminary histological examination revealed some tendency for the bronchial epithelium to undergo a squamous proliferation.

MDDC - 330 Toxicity Following Inhalation Of Fluorine And Its Gaseous Compounds, Hydrogen Fluoride, And Oxygen Fluoride. Part II. (Chapter X - The Pharmacology And Toxicology Of Uranium Compounds. For Part I-see MDDC-376), by H. E. Stokinger. 73p.

Exposures to OF_2 gas at concentrations ranging from 10 to 0.1 ppm indicated that while all concentrations down to 0.5 ppm were highly lethal, a sharp demarcation in toxic response occurred at the 0.1 ppm level. At this concentration neither mortality nor any indication of toxic response appeared in all of 4 toxicologic measures used.

Characteristics of inhalation exposures to OF_2 gas were:

(a) At 10 ppm respiratory convulsions, cyanosis, and death, accompanied by extremely severe pulmonary damage, within a matter of a few hours.

(b) At lower concentrations, but not including 0.1 ppm, OF_2 acted as a soporific and ultimately produced death in all animals exposed. Pulmonary damage was incurred.

Of the 3 gases, HF, F_2, and OF_2, OF_2 was the most toxic, the "tolerated" exposure concentrations for each of the 3 gases respectively being, 7, 1, and 0.1 ppm. This is equivalent to 6, 1.7, and 0.18 mg fluoride ion/m^3. This places OF_2 among the most toxic inorganic gases yet tested. The greater toxicity of OF_2 is brought out decisively from a comparison of the totally lethal concentrations of F_2 and OF_2. Two hundred parts per million was the lowest concentration of F_2 that was completely lethal for all species exposed, while only 0.5 ppm of OF_2 was required to produce the same effect, a lethal concentration ratio of 400 to 1. OF_2 is further distinguished from the other 2 fluorine gases in that tolerance was demonstrated to occur in rats following initial exposure. This tolerance could not be demon-

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MDDC - 330 Toxicity Following Inhalation Of Fluorine And Its Gaseous Compounds, Hydrogen Fluoride, And Oxygen Fluoride (Chapter X - The Pharmacology And Toxicology Of Uranium Compounds. For Part I-See MDDC-376), by H. E. Stokinger. 73p. (cont'd from page 193).

strated, however, until after a week had elapsed between the time of the initial and test exposures. While no experiments such as this were performed with either HF or F_2, it would appear that tolerance to these latter two gases is not a pronounced property, because animals died throughout the entire course of the 30-day exposures. Cessation of the mortality while exposure was still in progress would have indicated a tolerance. OF_2, moreover, possessed the property of a somnifacient in moderately tolerated concentrations. Soporific tendencies were noted, both in the animals exposed and also by personnel handling the gas. The capacity of the gas to produce sedation was pronounced, although that of producing sleep was not overpowering.

A comparison of the toxicologic results of F_2 and HF gas shows that F_2 produces a toxicity distinct from that of HF. This occurs despite the reactivity of F_2 with body fluids to form HF. Evidence for the distinct response of F_2 lies not only in its definitely greater toxicity but also in the fact that dogs and rabbits are killed by F_2 but rats and mice survive the same exposures. On the other hand, rats and mice are very susceptible to HF, but not dogs and rabbits. These species responses give striking evidence of the independent toxicity of F_2 and HF. Furthermore, less fluoride ion is retained in the bones of animals exposed to F_2 than in those exposed to an equivalent concentration of HF. In connection with deposition of F in bones, it is interesting to note that more fluoride is retained in new bone regenerated from biopsied mandible and maxilla of the dog than in comparable undisturbed structures.

It is pointed out that distinct differences exist in the action of the three gases as indicated by differences in over-all toxicity, in species response, and the rate of F-deposition in the bone. One major characteristic, however, common to all of the compounds, is the marked toxic action on the respiratory system. At lethal levels, death invariably resulted from severe pulmonary damage and at nonlethal levels, if any damage occurred, it was usually pulmonary damage. Although the fluoride gases are chiefly pulmonary irritants, they affect other organs to a lesser extent. There was considerable inflammation of the buccal membranes, eyes and scrotum, the latter accompanied by testicular degeneration at the levels used. High concentrations of fluorine under pressure are extremely hazardous, producing second-degree burns not unlike those from an oxyacetylene flame.

There is a marked accumulation of fluoride in the bones and also in the teeth. In fact, fluorosis of the teeth serves as a good indicator of F-exposure. In the case of the 25-mg level of HF, renal cortical degeneration was observed in the rats, but not in the dogs or rabbits. The presence of renal damage in the cases of OF_2 and F_2 is questionable, because in most cases only gross observations on dying animals were made.

One additional factor in toxicity of F-containing gases is concerned with the contamination of the fur. In the case of those animals that lick their fur, considerable material could be ingested. Also there was a prolongation of exposure by evolution of gases into the ambient air from the fur following removal of animals from the exposure chamber. These conditions resulted in a more severe toxic response in animals which were bodily exposed than in those which had only their heads exposed. In the case of fluorine gas, absorption by the fur was so great that its texture was affected.

MDDC - 331 Fluorination Of Petroleum Oils (II) - Reaction In The Liquid Phase With Silver Difluoride, by W. S. Struve, et al. 13p. (See also Industrial and Engineering Chemistry, Vol. 39, p.350-352, March 1947)

Attempts were made to find improved methods of preparing a substantially perfluorinated hydrocarbon oil, since the vapor phase reaction of hydrocarbon oils with elemental fluorine in the presence of a silver-plated copper catalyst gave but 15 to 25% of viscous perfluorinated hydrocarbons boiling in the range of 137 - 220°C. at 10 mm.

Attention was directed to the liquid-phase reaction of hydrocarbon oils with active fluorine carriers such as cobalt trifluoride and silver difluoride. The reaction of cobalt trifluoride with oils is very vigorous, sometimes occurring with explosive violence. It was found, however, that if either the cobalt trifluoride or the hydrocarbon oil was diluted with a medium molecular weight fluorocarbon, the fluorination proceeded smoothly, giving a fluorocarbon in 30-50% yields, based on the conversion of CH_2 to CF_2. The use of the less vigorous silver difluoride as a fluorinating agent gave even less breakdown of the hydrocarbon during fluorination, and yields as high as 80% were obtained. The following reactions are involved:

$$2\,AgCl + F_2 \longrightarrow 2\,AgF + Cl_2 \qquad (1)$$

$$2\,AgF + F_2 \longrightarrow 2\,AgF_2 \qquad (2)$$

$$-CH_2- + 4\,AgF_2 \longrightarrow -CF_2- + 4\,AgF + 2\,HF \qquad (3)$$

But very small amounts of breakdown products were recovered and it is believed that the products obtained were of the same carbon chain length as the original hydrocarbons.

The procedure consisted of adding the hydrocarbon oil slowly to a mixture of the medium molecular weight fluorocarbon, called the "solvent," and silver difluoride at 180°C. After being heated at 240°C, for twelve hours, the reaction mass cooled and the fluorocarbon mixture was extracted with trichlorotrifluoroethane.

The trichlorotrifluoroethane was stripped off and the fluorocarbons were separated by fractionation under 10 mm pressure. The fraction boiling at 137 - 220°C, at 10 mm, was collected.

Some properties of the finished product are:

Centistokes at 100°F	536
Centistokes at 210°F	9.05
Viscosity index	-674
Density at 20°C	2.0 g/cc
Density at 210°F	1.85 g/cc
Index of refraction	1.33 - 1.35

MDDC - 332 Statistical Methods (Chapter III - Pharmacology And Toxicology Of Uranium Compounds), by D. V. Tiedeman, L. S. Kogan, M. J. Wantman. 16p.

This report summarizes the statistical methods used to evaluate biological data from experiments performed at the University of Rochester. Examples are chosen to illustrate various computing methods: arithmetic mean, standard deviation, weighted mean and weighted standard deviation, correlation coefficients, regression equation, establishment of probability values and tests of significance, and Chi-squared tests.

MDDC - 333 A Report On The Hyperfine Structure In The Arc Spectrum Of Enriched Uranium, by O. E. Anderson, H. E. White. 8p. (See also Physical Review, Vol. 71, p.911, June 15, 1947

The hyperfine structure of an enriched sample containing 64 per cent of U^{235} has been investigated. From a study of the one visible arc line of which the splitting could be partially resolved, it is concluded that the nuclear angular momentum I of U^{235} is either 5/2 or 7/2. The two hyperfine intervals that are resolved do not obey the interval rule for either of these values, but the conclusion is drawn by comparing the intensity of the leading component with the overall intensity of the line (as judged by the single U^{238} line).

MDDC - 334 The Magnetic Moments of the Neutron and the Deuteron, by W. R. Arnold, A. Roberts. 4p. (See also Physical Review, Vol. 70, p.766 and Vol. 71, p.878-886, June 15, (1947)

The ratio of the magnetic moments were measured by a radio-frequency resonance method wherein neutron beams were polarized and analyzed by passage through ferromagnets. In the case of the neutron, the magnetic field was adjusted for proton resonance, using an arbitrary radio frequency near 30 Mc/sec. Without changing the magnetic field, the water sample used for proton resonances was removed from the r-f coil in the magnetic field, a neutron beam sent through the coil, and the neutron resonance found by varying the radio-frequency applied to the coil. The drop in intensity of the neutron beam at resonance was between five and eight per cent. The ratio of the magnetic moments, since the spins of both proton and neutron are one-half, is then the ratio of the two radio frequencies.

For the deuteron, the magnetic field was adjusted to resonance at a fixed frequency with a heavy water sample. Ordinary water was then substituted and the frequency varied until the proton resonance was found.

The mean of seventeen observations of the neutron-proton ratio gives the value 0.68479. Four observations on the deuteron-proton ratio give the value 0.30702. Since the possibility of systematic error cannot be excluded, however, the final values are regarded as 0.68479 ± 0.0003 for the neutron-proton ratio and 0.30702 ± 0.0001 for the deuteron-proton ratio. Taking the magnetic moment of the proton as exactly 2.7896 nuclear magnetons, since the theory depends only upon relative values, authors obtain for the neutron, inserting a minus sign, -1.9103 ± 0.001 nuclear magnetons, and for the deuteron 0.85647 ± 0.0003. Rabi and his co-workers give for the deuteron-proton ratio 0.30703 ± 0.0001, and for the absolute value of the magnetic moment of the deuteron 0.8565 ± 0.0004.

Rarita and Schwinger's predicted value for the neutron moment, corrected to use Rabi's latest values, is -1.9108. Conversely, using values in this study for the neutron-proton and deuteron-proton ratios, there is found in the ground state of the deuteron an admixture of 4.0 per cent $^3D_1$ state, as compared with 3.9 per cent deduced from the quadrupole moment.

MDDC -335 Note On Barium Plutonate (Mono-or Poly-Plutonate), by R. E. Connick, W. H. McVey. 2p.

In preparing pure solutions of Pu(VI), it is customary to start with a solution of Pu(IV), oxidize the plutonium to Pu(VI), and remove the excess oxidizing agent and its reduction products. This is done by precipitating the Pu(VI) as $NaPuO_2Ac_3$ and removing the excess oxidizing agent and reduction products with the supernatant solution. The $NaPuO_2Ac_3$ is then dissolved in acid and, in order to eliminate acetate, the Pu(VI) is precipitated as sodium plutonate by adding excess sodium hydroxide. Sodium plutonate is rather soluble and is slow to precipitate. It was therefore desirable to find a compound of Pu(VI) which is less soluble than sodium plutonate. In analogy to the compounds of U(VI), barium plutonate seemed to be a likely possibility. It was found that barium plutonate is, in fact, considerably less soluble than sodium plutonate and precipitates much more rapidly. The barium plutonate precipitate is light brown. The composition of this compound is unknown but it is presumed to be barium (mono-or poly-) plutonate.

In one experiment in which the barium ion concentration was 0.25 M and hydroxide ion concentration was 0.1 M, the solubility measured within 15 minutes after precipitation was 35 mg Pu/liter; and the solubility after ca 14 hours was 12 mg Pu/liter.

Recently, Pu(VI) solutions free of oxidizing agents have been prepared by the following method. The plutonium is oxidized to Pu(VI) by bromate in nitric acid solution. The Pu(VI) is then precipitated as barium plutonate to remove bromine and the excess bromate. The barium plutonate is dissolved in acid to give a plutonyl solution.

MDDC - 336 Note On The Oxidation Of Pu(III) By Chlorine, by R. E. Connick, W. H. McVey. 2p.

Thermodynamically chlorine is easily capable of oxidizing Pu(III) to Pu(IV) and even to Pu(VI). It was of interest to determine the order of magnitude of the rate of this reaction.

The solution used was 0.0052 M in plutonium of which 96% was Pu(III) and 4% Pu(IV). This solution was also 0.5 M in HCl and at the start of the reaction contained 1.6 moles of chlorine for every mole of plutonium. After addition of the chlorine, the solution was stirred and transferred to an absorption cell. The reaction, which was carried out at room temperature, was followed by analyzing the solution spectrophotometrically at convenient time intervals.

Table of Experimental Results

Time in hours	% Pu(III)
0	96
0.25	95
5.25	85
9.25	79
21.25	69
71.	52

It is seen that the reaction is not rapid under these conditions. The oxidized plutonium was present partly as Pu(IV) and partly as Pu(VI). The Pu(VI) was probably formed by the disproportionation of Pu(IV) rather than by the oxidation of PU(IV) to Pu(VI) by chlorine.

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MDDC - 336 Note on the Oxidation of Pu(III) by Chlorine, by R. E. Connick, W. E. McVey. 2p. (Cont'd from page 198).

The concentration of chlorine during the course of the experiment cannot be definitely stated because unknown losses occurred during the stirring and transferring of the solution; however, these losses probably amounted to less than half of the initial chlorine.

MDDC - 337 Note on the Oxidation of Pu(III) by Nitrate Ion, by R. E. Connick, W. H. McVey. 6p.

A Pu(III) solution was prepared by reduction of Pu(IV) with hydrogen gas, using a platinized platinum foil as a catalyst. After reduction, the solution was made 0.5 M in hydrochloric acid and was found to contain less than 1% Pu(IV) when analyzed spectrophotometrically. The plutonium concentration was 5.7×10^{-3} M. Solid sodium nitrate was then added to make the solution 0.2 M in nitrate ion, and the solution was allowed to stand for eighteen hours at room temperature. Little, if any (< 2%), oxidation occurred in this time. Additional sodium nitrate was then added to make the solution 0.5 M in nitrate ion and the solution was heated approximately one minute at 100°C. The solution was then found to contain 39% Pu(III). The solution was next heated for 5 minutes at 100° C. It was found that 72% of the Pu(III) had been oxidized. There was a large amount of Pu(VI) present. Finally, after heating an additional 15 minutes at 100° C, 87% of the Pu(III) was found to be oxidized to Pu(IV) and Pu(VI).

Another PU(III) solution containing 10 mg of plutonium was prepared by hydrogen reduction and the hydroxide was precipitated in a nitrogen atmosphere. To the precipitate was added 0.1 ml of 16 N nitric acid. For a few seconds after the precipitate had dissolved, the solution had the characteristic color of Pu(III) but then quickly changed to the yellow-green color of Pu(IV). Hence, the oxidation of Pu(III) at high nitric acid concentration appears to be quite rapid.

In each of the above experiments there was some evidence of an autocatalytic effect in the reaction. Thus in the second experiment no change was noted during the first few seconds of the reaction, but the reaction then appeared to go to completion quickly once it had started. In the first experiment no appreciable reaction was observed during eighteen hours at room temperature using 0.2 M NO_3. When the

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MDDC - 337 Note on the Oxidation of Pu(III) by Nitrate Ion, by R. E. Connick, W. H. McVey. 6p.
(cont'd from page 199).

nitrate concentration was raised to 0.5 M and the solution heated one minute at 100° C, over half of the Pu(III) was oxidized. It seems likely that the great increase in rate in going from room temperature to 100° C is partly due to an autocatalytic effect rather than to the heat of activation alone, which would have to be extremely great to explain the results.

Small amounts of NO and HNO_2 can be expected to catalyze the oxidation of Pu(III) by nitrate ion. A similar effect would be found for solutions containing NO_2 or N_2O_4. Therefore, the stability of Pu(III) in nitric acid solutions depends on the purity of the solutions with respect to compounds of lower oxidation states of nitrogen.

MDDC - 338 Note on the Oxidation of Pu(III) by Oxygen, by R. E. Connick, W. H. McVey. 2p.

Oxygen was bubbled through a $Pu(OH)_3$ solution in dilute HCl containing 3.1% Pu(IV) for 20 minutes, the cone was sealed, and the solution allowed to stand for 42 hours. At the end of this time, spectrophotometric analysis showed there was 3.2% Pu(IV) present.

A second Pu(III) solution in which the total plutonium concentration was 0.0052 M, of which 1.5% was Pu(IV), was prepared. This Pu(III) solution was heated at 60°C in a water bath and oxygen was bubbled through the solution for 20 minutes at this temperature. There was 1.8% Pu(IV) found to be present in the solution after this treatment. Next, the solution was heated to 90° in a water bath and oxygen was bubbled through the solution for 20 minutes. Analysis showed the presence of 2.7% Pu(IV). Finally, the solution was sealed in a Pyrex cone. The air space above the liquid was swept out with oxygen before sealing. The cone was heated at 97°C for four hours. The space above the solution contained a 20-fold excess of oxygen over that necessary for the complete oxidation of Pu(III) to Pu(IV). On analysis, 4.0% Pu(IV) was found to be present.

From these experiments it would appear that Pu(III) is oxidized only very slowly by oxygen in 0.5 M hydrochloric acid, even at elevated temperatures. This slowness of reaction is consistent with the rates of oxidation by oxygen of other substances, such as Fe^{++}. The mechanism of oxidation by oxygen in acid solution in general involves the formation of hydrogen peroxide as an intermediate. It is known that hydrogen peroxide reacts with Pu^{+3} in 0.5 M HCl at only a moderate rate. In addition, the concentration of hydrogen peroxide must always be extremely small during the oxygen oxidation reaction because of the low reducing power of Pu^{+3}. These two facts make it necessary that the reaction proceed only very slowly. The faster oxidation in the case of iron as compared to Pu(III) is to be correlated with the greater driving potential for the iron reaction.

MDDC - 339 The +3 Oxidation State of Plutonium, by R. E. Connick, W. H. McVey, G. E. Sheline, 8p.

Since plutonium is highly colored in its +4 and +6 oxidation states, experiments were first tried to see if hydroxylamine would produce a color change. To 244 micrograms of Pu^{+4} in a nitric acid solution was added enough hydroxylamine hydrochloride to give a solution of the following composition: 0.14 M Pu^{+4}, 1.7 M H^+, 0.3 M NH_3OH^+. Prior to the addition of the hydroxylamine, the solution had the characteristic green color of the +4 state. Immediately after adding the hydroxylamine, no color change was detectable. However, within 6 minutes the solution began to take on a blue cast and after standing several hours at room temperature changed to a very beautiful blue color. The hydroxylamine must have profoundly affected the condition of the plutonium, and the most likely explanation was that it had reduced it to a lower oxidation state.

Determination of the Oxidation Number of the Blue State.

After obtaining precipitates of the blue reduced state, two experiments were performed to establish the oxidation number. The general procedure was to reduce Pu^{+4} to the blue reduced state, using NH_3OHCl as the reducing agent. The plutonium was then precipitated as the light blue double sulfate by adding enough K_2SO_4 to give a HSO_4^- - $SO_4^=$ buffer. The sulfate precipitate was dissolved in 1 M HNO_3. An excess of $K_2Cr_2O_7$ was added and the blue reduced state was rapidly oxidized to the +4 state by the dichromate. The Pu^{+4} was removed from the solution by precipitation with sodium hydroxide and the supernatant solution was titrated for the amount of $Cr_2O_7^=$ that was not used up in the oxidation of the plutonium.

The detailed procedure for the first experiment was as follows:

The starting solution (volume 40 μl) had the composition: 0.032 M Pu^{+4} (309 μg total), 0.9 M HNO_3, 0.4 M NH_3OHCl.

7 mg K_2SO_4 plus 40 μl of 0.5 M K_2SO_4 solution were added. The light blue double sulfate precipitated.

The supernatant solution was removed and was found to contain 10 μg of plutonium.

The sulfate precipitate was washed twice with 30 μl portions of 0.1 M $KHSO_4$. Analysis of the washes showed that a total of 40 μg of plutonium had dissolved. Such a large loss could have been avoided by using a $KHSO_4$-$KHSO_4$ buffer wash solution.

To the double sulfate were added 40 μl of 1 M HNO_3 and 1.860 μl of 1.195 N $K_2Cr_2O_7$. The precipitate dissolved readily and the plutonium in the blue oxidation state was rapidly oxidized to Pu^{+4}.

The solution was diluted with 30 μl of water and the plutonium precipitated as the +4 hydroxide on addition of 10 μl of 10 N NaOH. The precipitate was dark green.

The supernatant solution was removed and the precipitate was washed once with 40 μl of 0.2 M NaOH.

To be sure that all of the $CrO_4^=$ had been removed from the precipitate, the precipitate was dissolved with 5 μl of 10 N HNO_3, diluted to 65 μl with water and reprecipitated with 10μl of 10 N NaOH. The supernatant solution was removed and the

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MDDC - 339 The +3 Oxidation State Of Plutonium, by R. E. Connick, W. H. McVey, G. E. Sheline. 8p. (cont'd from page 201).

precipitate washed with 40 μl of 0.2 M NaOH. (On analysis the precipitate was found to contain 257 μg of plutonium.)

The two supernatant solutions and the two washes from the hydroxide precipitations were combined. (Analysis showed 1.8μg of plutonium to be present in this solution.)

To the combined solutions were added 60 μ l of 5 N H_2SO_4, 5μl of 85% H_3PO_4 and 40μl of 0.02% barium diphenylamine sulfonate indicator solution. The solution was titrated for $Cr_2O_7^=$ against standardized ferrous ammonium sulfate solution.

Blank experiments were run using La^{+3} in place of the blue reduced plutonium and Th^{+4} in place of the Pu^{+4}. The blanks were carried through all of the above procedure, and corrections amounted to ~10%.

The experimental results are tabulated. The two values obtained for the equivalents of dichromate consumed per mole of plutonium oxidized are 1.08 and 0.93, respectively. Thus, in oxidizing the plutonium from the blue state to the +4 state, a change in the oxidation number of one unit occurred. Therefore, the blue state is the +3 oxidation state of plutonium.

MDDC - 340 Simultaneous Photography of Two Spectral Regions in Chemical Analysis, by J. Conway, N. H. Nachtrieb, E. D. Wilson. 7p.

Two arrangements are presented, by means of which the complete spectrum of a sample from 2250 to 7100 Å may be obtained in a single exposure. One system, employing a single grating spectrograph, utilizes two slits of the instrument, and produces juxtaposed spectra of two wave-length ranges on the same film. The second method employs two spectrographs aligned in opposition, and passes portions of the light emitted from the source through the slits of both instruments.

MDDC - 341 Integrating Polonium Meter, by T. R. Cuykendall, L. T. Finlayson. 7p.

A simple parallel-plate atmospheric-pressure type of ionization chamber for quick determination of strength of polonium samples is described. Ion current was found to be linear with strength of source up to at least 10 millicuries. With accelerating voltage of 6 kv employed, no changes were found necessary in the general design of the chamber. The area of the polonium foil, the number of foils, or position within the chamber is not important within the range described in the report.

MDDC - 342 Report on Determination of the Thermal Conductivity of Sodium-Potassium Alloy at Elevated Temperatures, by Herbert Deem, H. W. Russell. 9p.

The thermal conductivity of an alloy consisting of approximately 50 per cent sodium and 50 per cent potassium by weight was determined over a temperature range of approximately 100°C to 500°C. The thermal conductivity of the alloy in watts cm^{-2} cm. $^{\circ}C^{-1}$ was 0.258 at a mean temperature of 100°C and 0.284 at a mean temperature of 500°C. The thermal conductivity increased linearly with temperature.

MDDC - 343 The Complex Ions Formed by Thorium and Iron With Fluoride in Acid Solution, by H. W. Dodgen. 44p.

The purpose of this paper is to present results on the complexing of ferric ions and thorium ions by fluoride in acid solution.

The potential of the Fe^{+3} - Fe^{+2} electrode is studied as a function of the HF and H^+ concentration, and it is shown that the data can be interpreted quantitatively by assuming the existence of the complexes FeF^{++}, FeF_2^+, and FeF_3.

After the Fe^{+3} - Fe^{+2} electrode had been studied, it was possible to interpret the data for cells containing thorium by assuming the existence of the complex ions ThF^{+++}, ThF_2^{+++}, and ThF_3^+. The solubility product of $ThF_4 \cdot 4H_2O$ was also determined.

MDDC - 344 Measurement of Weak Neutron Intensities by Szilard-Chalmers Reaction in Calcium Permanganate Solution, by R. W. Dodson, M. Goldblatt, J. H. Sullivan. 16p.

A sensitive method for measuring the intensity of weak neutron sources by measuring induced Mn^{56} beta activity after concentration by a Szilard-Chalmers process has been developed. The practical detection efficiency for Ra-Be neutrons is 7.8%; the procedure is capable of detecting a neutron intensity of about one neutron per second.

MDDC - 345 Spectrochemical Analysis by the Copper Spark Method, by M. Fred, N. H. Nachtrieb, F. S. Tomkins. 24p. (See also Journal of the Optical Society of America, Vol. 37, p.279-288, April 1947.)

A system of spectrochemical analysis is described in which a drop of a hydrochloric acid solution is evaporated on the ends of a pair of flat-topped copper electrodes which are then excited in a spark. Absolute sensitivities ranging from 10^{-10} to 10^{-6} gram have been obtained. The lower limits measurable by visual comparison with standard plates are listed for about 60 elements. The visual method gives results accurate to a factor of two over a range from the lower limits up to about 10 micrograms. The accuracy can be increased, with some loss in sensitivity, by densitometry with an internal standard, an average deviation from the mean of 3 to 8% being obtained, depending on whether a spectroscopic buffer is used. In addition to high sensitivity the method has the advantage that a great many elements can be determined in one exposure, so that almost any sample which can be obtained in HCl can be analyzed for impurities without special calibration.

The method was developed for the analysis of plutonium samples and is the result of considerable cooperative effort. No special mention of the plutonium application is described in this paper.

MDDC - 346 Differential Pressure Indicator, by General Electric Company, Apparatus Division. 43p.

This document is a manual containing installation and operating instructions for the instrument.

MDDC - 347 Chemical And Physical Properties Of Fluorocarbons, by A. V. Grosse, G. H. Cady. 20p. (See also Industrial and Engineering Chemistry, Vol. 39, p.367-74, March 1947.)

The physical and chemical properties of completely fluorinated compounds of C are reviewed, with 26 references. Due to the strength of the C—F bond it is possible to form compounds analogous to all hydrocarbons. It is suggested that such fluorocarbons be given the usual name, prefixed by ϕ, e.g., ϕ-heptane, C_7F_{16}. The direct substitution of H by F in an organic molecule is an extremely exothermic reaction and saturated fluorocarbons thus formed are thermally and chemically stable. In the presence of catalysts F is partly replaced by H at high temperature and pressure. Fluorohydrocarbons are more reactive than fluorocarbons. Fluoroolefins show typical double-bond reactions but are unreactive as far as the C—F bond is concerned. Fluorocarbons are usually volatile due to very low molecular attractive forces. Melting points are usually higher than in the hydrocarbons, and the density increases more rapidly with addition of C atoms. Refractive indexes are very low. The best value for AR_F (atomic refractivity for F) is 1.23 ± 0.01, but this value changes with the number of F atoms in the molecule in the gasoline range. Viscosity is high and the temperature coefficient of density and of viscosity is very high. Saturated fluorocarbons are insoluble in H_2O alcohols and hydrocarbons, but soluble in chlorocarbons.

MDDC - 348 Penetration Of Gamma Rays Through Thick Layers, by M. H. Hull. 22p.

A method is worked out to account for angles of photon scattering as a gamma ray is degraded energetically by passage through a medium. Ionization is calculated for both a point source and an extended source theoretically.

MDDC - 349 Properties of 94^{239}, by J. W. Kennedy, G. T. Seaborg, E. Segre, A. C. Wahl. 5p. (See also Physical Review, Vol. 70, p. 555-556, October 1946).

The cross section for the fission of 94^{239} with slow neutrons is larger than that of U^{235}. The cross section was determined by comparing the number of fissions obtained from a sample containing 94^{239} with the number obtained from a sample of ordinary uranium, under conditions which were identical as possible in every detail. Two separate methods were used to prove that the fissions in the 94^{239} sample could not be attributed to the presence of uranium impurity: (1) complete and identical chemical tests on the isolation of rare earth carrier material for element 94 from non-irradiated uranium, i.e., "blank tests," in which the absence of uranium impurity in the final product was established by showing the absence of uranium alpha-particles and (2) demonstration that the ratio of the cross section for slow neutrons to that for fast neutrons for the fission of 94^{239} is different from the same ratio for natural uranium. 94^{239} has an alpha activity with a half-life of 3×10^4 years.

MDDC - 350 Snouting and Focusing the Cyclotron Beam, by L. S. Lavatelli. 21p.

The steps necessary to get an external beam down a snout section and the equations for focusing a beam magnetically are given. These equations, together with the initial beam configurations and other constraints, are solved simultaneously approximately to yield suitable design for a focusing chamber. The chamber enabled a beam of about three microamperes to be focused on an area of one square inch at a point 20 feet distant from the target chamber of the cyclotron.

MDDC - 351 Inorganic Separations Using Ion Exchange, by G. P. Monet. 12p.

In this report, Unit Operations in Ion Exchange, the general procedures used in chemical separation, the equipment used, and the theory of the exchange equilibria and of the reaction rates are presented.

Subjects covered include:

Physical characteristics of resins
1. Composition and properties of a typical resin, Amberlite IR-1
2. Volume changes in resin column operation

Chemical separation processes
1. Batch operation
2. Column operation (Selective elution, volume separation, and precipitation separation)

Separations process equipment
1. Batch operation
2. Column operation
3. Thin-bed operation

Theory of the exchange reactions
1. Equilibria of the cation exchange reactions
2. Rate of exchange in batch and in column

MDDC - 352 The Self-Diffusion Coefficient of Uranium Hexafluoride, by E. P. Ney, F. C. Armistead. 15p. (See also Physical Review, Vol.71, p.14-19, January 1, 1947)

A method has been developed and successfully used for the measurement of ρD (ρ = density; D = diffusion-coefficient) for an isotopic mixture. The D thus measured should be a close approximation to the true self-diffusion coefficient. Two vessels were filled with UF_6 vapor of different isotopic concentrations but equal pressure. To start the experiment, the material in the two vessels was allowed to diffuse through a connecting pipe. The isotopic ratio in one vessel was measured as a function of the time with a mass spectrometer into which a very small sample was continuously being drawn. The isotopic ratio measured by the mass spectrometer is an exponential function of the time. The relaxation time together with the dimensions of the apparatus give the self-diffusion coefficient. Knowledge of the pressure allows calculation of ρD. The value of ρD at 30°C is 234 micropoise $\pm$ 5 percent. Classically ρD is associated with the viscosity through the equation $\rho D = \epsilon \eta$, where ϵ is a pure number whose value is determined by the force law interaction of the molecules. Therefore, knowing the ratio of ρD to the viscosity, one can determine the force law interaction.

MDDC - 353 Evaluation of Scattering Data, by P. Glum. 45p.

This report discusses a method for evaluating the results of experiments on the scattering of neutrons by disks of various materials. The analysis attempts to take account of multiple scattering, of depletion of the beam in the scatterer, and of energy losses in scattering from light elements, which have not been adequately considered in previous approximate evaluations. Since the experiments of group R-3 were done with several different biases on the detector, both elastic cross sections and cross sections for inelastic scattering below the various biases were calculated. The results are contained in a table which gives transport cross sections, inelastic cross sections, and average elastic cross sections in various angular range; these latter results on the angular dependence are somewhat less reliable, however. The materials included in the table are Al, B^{10}, B^{11}, Be, BeO, C, Ar, Fe, Pb, and W. The results are given for four different neutron energies (200, 600, 1500, and 3000 Kev) for the heavy elements, and two energies (600 and 1500 Kev) for the light elements. At each energy the cross sections are tabulated as a function of the bias on the detector, generally two or three different biases are given.

MDDC - 354 Contributions To The Radiochemistry of 104-day Y^{88}, by R. T. Overman. 8p.

A sample of Y^{88} was obtained by bombarding Sr with deuterons in the 60" Berkeley cyclotron. Also, an irradiation of yttrium, which is 100% in abundance of mass 89, in a field of high energy neutrons, was made. These neutrons would be expected to produce an (n,2n) reaction on the yttrium, giving rise to an activity which could be assigned to Y^{88}, since it is unlikely than an (n,4n) reaction is possible. From the decay and absorption curves, data were obtained for the activities produced. These data are summarized in the table and show that both the (n,2n) and the (n,p) reactions took place. No inspection of the material for rubidium, which would be produced from an (n,α) reaction, was made.

Half-life of Activity	% Present (Calc. to satn.)	Feather Range mg/cm^2	Energy Mev Obs.	Energy Mev Publ.	Isotope Assign.	Reaction
2.0 hours	5.4	760	1.65	1.2	Y^{88}	(n,2n)
60.0 hours	80.3	1200	2.6	2.6	Y^{90}	(n, γ)
55 days	8.9	865	1.9	1.9	Sr^{89}	(n, p)
104 days	5.4	hard gamma	(1.2)	(0.9, 1.9)	Y^{88}	(n,2n)

The curve obtained from a combination of 0.9 and 1.9 Mev corresponds to the curve taken from the yttrium obtained from strontium bombardment. The published energy of the positron associated with the 2.0-hour activity is 1.2 Mev. If the higher energy level isomer is assumed to be correct at 2.8 Mev, the value of 1.65 Mev gives much better agreement with the theory of independent isomerism. The cross section of the formation of the isomeric states is approximately equal, and there is no isomeric transition evident within the accuracy of the data.

MDDC - 355 Properties and Measurement of C^{14}, by A. F. Reid, S. Weil, J. R. Dunning. 20p.

In 1940, Ruben and Kamen reported the existence of a long-life, weak β-emitting isotope of carbon, C^{14}. This could be produced by a number of nuclear reactions

$$C^{13} + n \longrightarrow C^{14} + \gamma \quad (1)$$
$$C^{13} + H^2 \longrightarrow C^{14} + H^1 \quad (2)$$
$$N^{14} + n \longrightarrow C^{14} + H^1 \quad (3)$$

Its value as a tracer was recognized immediately, but because of the low energy of the β-ray and its long life (> 1000 years) its utility was contingent on the development of a sensitive and quantitative measurement technique.

This paper lists the properties of C^{14} important to measurement, and gives a detailed outline and examples of procedures and techniques for effective C^{14} analysis using a thin-window Geiger counter. β-ray absorption effects are discussed, as well as the systematic calibrations which must be made when using a counter system for detection.

MDDC - 356 Determination Of Oxygen By The Vacuum Fusion Method, by C. N. Rice. 10p.

Description is given of the alterations made in the apparatus and technique of the vacuum fusion method for oxygen determination used at Los Alamos. The changes for the most part involve the construction of the high vacuum system, the use of a micro-diffusion pump, and the substitution of a multiple loading system for the single loading arrangement. With the changed apparatus and techniques, analysis of six uranium-metal samples may be performed in a fifteen-hour period.

MDDC - 357 Tension And Compression Tests Of Pure Bismuth, by A. U. Seybolt. 3p.

The compression samples, 0.374 in. diameter by 1 in. high cylinders, were prepared by casting into 1 1/4 in. high aluminum tube lengths, ½ in. inside diameter. The aluminum tubes were machined away on a lathe, finishing the bismuth specimens to the dimensions given above.

The tension specimens were 6 in. long, 3/4 in. wide, 0.120 in. thick. The reduced gauge length was 0.500 in. wide, 2 in. long, shoulder radius 2 in. These were cut from chill cast slabs 3/16 in. thick by 5 in. by 6 in.

The cylinders were tested in a specially designed compression jig insuring axial loading, and the deformation was measured with a 0.001 in. dial gauge fitted to the jig. Four samples were tested with the results given below.

Compression Strength of Bismuth

Sample	Yield Strength, psi (0.2% offset)	Young's Modulus, psi
1	1970	650,000
2	1590	660,000
3	1550	530,000
4	1620	490,000
Average	1680	582,500

The flat tension specimens were held in Templin-type grips, but otherwise no precautions to obtain axial loading were taken. Stress was applied at the rate of 0.03 in/min. The results are shown in the following table. Because no extensometer was available, only the ultimate tensile strength and per cent elongation are given.

Tensile Strength of Bismuth Samples

Sample	Ultimate Tensile Strength psi	Per Cent Elongation in 2 inches
1	2700	3
3	1940	1.5
4	1910	2.5
5	1950	2.5
6	2220	2.5
7	2010	< 1
8	2150	3
9	2130	3
10	1780	1.5
11	1810	1.5
Average	2060	2.2

MDDC - 358 **An Attempt To Observe The Radioactivity Of The Neutron, by E. F. Shrader, D. Saxon, A. H. Snell, 5p.**

Experimentally, there would seem to be three ways of observing the radioactivity of the neutron. One is to place a closed vessel in a region of high neutron flux, and to look for a gradual increase in the hydrogen content. Such an experiment has been in fact suggested by Wang. A second is to look for the beta rays, and a third is to look for the product protons by electrical counting methods. Of the three, the third seemed most promising from the standpoint of separation from background effects. An instrument was developed to count the positive ions (decay protons) in a neutron beam from the Clinton pile.

It is impossible to state at the moment that the neutron decay has been definitely observed. However, counts were obtained, and these counts decrease when a boron shutter is interposed. However, they decrease by only a small amount, viz., from 137 to 106 per minute. This means that there are background effects which must be reduced before a clear answer is obtained. This may be a long process.

The backgrounds have been found to be not due to the catcher which finally stops the beam, nor to scattering from the entrance window (experiment of putting extra aluminum in front of window). A mica sheet across the entrance to the multiplier tube served to segregate gamma ray counts from counts due to collection of positive ions; the result showed that the total background had contributions from both causes (the gamma effect is much the smaller), and established the gain level needed for rejection of the gamma pulses. The positive ion contribution is at present thought to be (partly at least) due to ionization of the residual gas in the vacuum system by slow secondary electrons emitted from the walls of the vessel and from the aluminum window. Part of the evidence for this consists of the presence of a rather strong pressure effect. Efforts are now being devoted to the attainment of better vacuum, and the suppression of the electrons by other means.

MDDC - 359 **The Scattering Of Slow Neutrons By Ortho And Parahydrogen, by R. Sutton, et al. 29p.**

The observed values of the ortho and parahydrogen scattering cross sections are consistent with a free proton scattering cross section of about 21 x 10^{-24} cm^2; for a square-well n-p interaction the implied range is a = 1.7x10^{-13} cm, experimental error and correlation with the free proton cross section allowing the value to lie between a = 1.6 and a = 2.3x10^{-13} cm.

MDDC - 360 **Radioactive Threshold Detectors For Neutrons, by R. F. Taschek. 15p.**

Of nine (n,p) and (n,α) reactions studied, only Be^9 (n,α)He^6, P^{31}(n,p)Si^{31}, and S^{32} (n,p) P^{32} gave measurable activities of the residual nucleus after bombardment by neutrons below 2 Mev, and of these three only P^{31} (n,p)Si^{31} had the combination of cross section and half-life to make a very practical threshold detector for neutrons. The 4.1-hour non-capture excitation of In was investigated as a function of neutron energy. The threshold and variation of cross section with energy of the P^{31} (n,p)Si^{31} reactions were measured in detail.

MDDC - 361 Long Electrostatic Generator Improvements, by C. M. Turner. 20p.

In the interest of extending various cross section measurements to higher neutron energies, it was decided in November 1944, to instrument the long electrostatic generator for D-D operation, using a deuterium gas target, with the deuteron beam entering the gas chamber through a foil. Inasmuch as the top practical operating voltage of the generator is about 3.7 million volts, the maximum neutron energy available from such a target is 6.6 Mev, if the stopping power of the foil is 400 kilovolts. While the yield to be expected from such a target was somewhat uncertain, estimates indicated that with a stopping power of about 100 kilovolts in the deuterium gas, the yield would be adequate for most purposes, and later results showed this to be true.

During the course of the work with the long tank, and particularly while instrumenting for D-D operation, a number of incidental improvements were made which have added to the general convenience and reliability of operation. These improvements include the following: (1) rotating lithium target; (2) new-type vacuum valves; (3) magnetic beam shutters; (4) liquid-air trap; (5) palladium leaks; (6) corona energy control; (7) revised high-voltage electrode setup. Brief descriptions are given of the above mentioned apparatus and circuit diagrams, and mechanical diagrams of the apparatus are included in the paper.

MDDC - 362 Neutron Absorption Method For Boron Analysis, by R. Walker. 4p.

A method is described for analyzing suitable substances for their boron content. The method is applicable only to substances which do not contain strongly absorbing elements other than boron, and substances which are either soluble or so finely divided that the self-absorption for slow neutrons of a single grain is small. The measurement consists of finding what weight of the substance to be analyzed, when distributed uniformly throughout a fixed volume of water, will produce the same absorption of slow neutrons per cm^3, as a given weight of boric acid crystals, distributed in the same way.

The fraction of boron in the B_4C was determined as 58.9%. A chemical analysis of the B_4C from the same carton gave 69.5% boron. No explanation is given for the discrepancy. The results are given of an analysis made on 600 mesh B_4C.

MDDC - 363 Chemical Effects Of Ionizing Radiation On Simple Inorganic Compounds And Aqueous Solution, by A. O. Allen. 15p.

Review of existing data shows that all covalent compounds are decomposed by ionizing radiations, but that for simple molecules the reactions often will not proceed far because of back-reaction of product molecules to re-form the original substances. Such systems are characterized by approach to radiation steady states, in which the various possible molecules are all present in proportions which will in general depend on the radiation intensity as well as on other variables. The concept of the constant "ion-pair yield" or "radiation yield" is valid only over restricted ranges for systems far removed from a steady state. New experiments on the decomposition of pure liquid water are described, which show that the water decomposes to hydrogen and hydrogen peroxide or oxygen, but if these products are not continuously removed from the water, a steady state is reached at very low product concentrations and decomposition ceases. Statements in the literature, apparently contradictory, on the radiation stability of water are shown to be reconciled by this scheme. The mechanism of water decomposition is discussed in detail in terms of behavior of free radicals formed by dissociation of the H_2O molecule. These radicals react readily with most solutes, and the decomposition of water by radiation is accordingly greatly affected by traces of dissolved material. Radiation effects in aqueous solutions are discussed in terms of free radical reactions. Applications to systems of biological interest are briefly indicated.

MDDC - 364 Analysis Of X-ray Powder Diffraction Data On Crystalline Uranium Hexafluoride, S. H. Bauer. 15p.

Two alternate explanations are suggested for the apparent discrepancy between the structure proposed for UF_6 as deduced from X-ray diffraction work on single crystals and from the electron diffraction investigation of the vapor. The second explanation is based on the premise that the difference may be due to essentially unlike methods of treating the diffraction data. This report analyzes X-ray powder photographs following a scheme parallel to that used in the analysis of the electron diffraction data, to check whether this particular explanation is tenable.

This work has not been able to answer the question whether the discrepany between the X-ray and electron diffraction structures arises from the different manner of treating the diffraction data. A further study of the absorption correction and an extension of the pattern to larger s values through the use of Mo or Ag radiation may permit an unambiguous answer to be made. However, judging from the widths of the radial, distribution peaks usually reported for liquids (-0.6A) it will not be possible to deduce many details of molecular structure from the analysis of powder data.

MDDC - 365 Radiochemical Analytical Methods, by G. E. Boyd, D. N. Hume. 46 p.

This report discusses the advantages and benefits as a tool to science that radiochemistry offers. The authors discuss the methods and techniques of applied radiochemistry; laboratory practice in the determination of alpha, beta, and gamma radiation; counting techniques; the preparation of radioisotopes; the use of radioactive indicators in shortening the analysis time required for complex samples; activation methods for the analysis of trace impurities; radiometric methods of analysis; and analysis for uranium.

MDDC - 366 Determination Of Oxygen In Uranium By Vacuum Fusion, by L. Brewer. 47p.

An apparatus for analysis of metal samples for oxygen content is described. Vacuum fusion in a graphite crucible which is insulated by porous carbon in an all Pyrex glass apparatus is used to remove the oxygen as carbon monoxide. Temperatures over 2000°C are attainable with a 6 K.V.A. Ajax converter for induction heating.

Successful operation depended upon a preliminary vacuum heating of the carbon parts at 2100°C to remove hydrocarbon tars so that cracking of the Pyrex glass will not occur due to deposit of tar. An operating temperature of 1750°C — 1800°C has been found satisfactory for uranium when using a platinum bath. The platinum bath is the most suitable bath because of its low volatility, its satisfactory carbon solubility, and because of the decrease of "getting errors" due to volatility of reactive metals. Most metals form stable compounds with platinum and are therefore strongly held by the platinum bath and cannot vaporize and thus react with the escaping CO gas. The degassing temperature is 2000 -2100°C and the blank has been reduced to as low as 0.3 cubic millimeters per minute at 1800°C, which allows analysis of samples of 50 -200 mg size which react completely within two minutes. Analysis of the standard Ames ingot gave a maximum oxygen content of about 45 ppm with a blank of 8 ppm. Analysis of a Westinghouse slab gave a maximum oxygen content of 30 ppm.

MDDC - 367 A High Temperature High Vacuum Apparatus, by L. Brewer, L. A. Bromley, P. W. Gilles, N. L. Lofgren. 35 p.

In connection with the program of preparation of oxygen-free sulfide crucibles and the study of metal casting at Berkeley, considerable experience has been gained in the attainment of high temperatures in high vacuum systems. Construction and operation of the apparatus is described in detail.

Temperatures up to 2500°C have been obtained with vacuums better than 10^{-4} mm while hot. Pressures better than 10^{-5} mm Hg are obtainable in the cold system. With small charges the temperature can be raised as rapidly as 1000°C per minute. The apparatus is built of Pyrex glass and requires no expensive quarts tubes, and yet no tubes which have been properly annealed have been known to crack from thermal strains. Well over 100 successful runs have been completed.

MDDC - 368 The Low-Temperature Heat Capacities, Enthalpies, and Entropies Of UF_4 and UF_6, by F. G. Brickwedde, H. J. Hoge, R. B. Scott. 23p.

The heat capacity of UF_4 has been measured for 20° to 350°K and that of UF_6 from 14° to 370°K. Molar heat capacities have been tabulated at 5 degree intervals and extrapolated to 0°K. From them the entropies and enthalpies of the compounds have been found by integration and tabulated. The triple point temperature of UF_6 was found to be 337.212°K (64.052°C) and the heat of fusion was found to be 19.193 j mol^{-1}.

MDDC 369 **The Platinum Metals (Analytical Chemistry Of The Manhattan Project - Chapter XXXVI), by C. W. Cressman, C. J. Rodden. 21p.**

Uranium metal, uranium compounds and in a few instances ores and residues, have been analyzed for trace amounts of the platinum group of metals: platinum, palladium , iridium, rhodium, ruthenium, and osmium. Materials used as catalysts were analyzed for macro amounts of platinum.

Methods are given for the determination of the above mentioned group of metals.

MDDC - 370 **The Mass Spectrograph In Chemical Analysis, by A. J. Dempster. 8p.**

A description is given of the manner in which the mass spectrograph is used in analyzing the ions of solid samples produced by the vacuum spark. This source combined with a double focusing mass spectrograph has proved very useful in the study of the isotopes of many elements. The techniques involved and the physical capabilities of the instrument are discussed. Illustrations are made by photographs of the spectra of uranium, ionium, thorium, and of ilmenite showing the impurities that occur.

MDDC 371 An Electrophoretic Study Of The Effects Of X-Rays On The Plasma Protein Pattern In Dogs, by J. A. Muntz, E. S. G. Barron, C. L. Prosser. 21p.

The administration of a lethal amount of X rays administered as a totalbody dose to dogs produced no characteristic change in the plasma protein pattern for one week following the treatment. From the seventh day after X irradiation until death of the animal, the albumin diminished steadily. Coincident with the onset of fever there was a striking increase in alpha$_3$ globulin and some increase in the beta globulin - fibrinogen fraction. Despite an increased blood volume in the terminal period, the total protein N was somewhat increased, a reflection of the sharp rise which is observed in the globulins. The increase in plasma globulin by electrophoretic analysis was not due primarily to an increase in plasma lipids. The injection of bovine albumin had no effect other than to raise the plasma albumin temporarily.

MDDC - 372 Copper, Silver, and Gold (Analytical Chemistry of the Manhattan Project), by T. D. Price, R. E. Telford. 19p.

Since the analytical chemistry of copper has been well summarized in standard reference books, the present treatment is designed to cover only analytical improvements and new applications of copper analysis as was used on the Manhattan Project.

Among the methods discussed are the salicylaldoxime precipitation method for Cu in UF_4, a volumetric method for Cu in process solutions and process solids involving iodometric titration, the colorimetric determination of copper with sodium diethyldithiocarbamate, the colorimetric determination of Cu with dithizone, a polarographic and spectrographic method for Cu, and colorimetric and spectrographic methods for the determination of silver and gold employing p-dimethylaminobenzilidenerhodanine in the colorimetric method and copper spark and carrier distillation for the spectrographic method. There is also given a colorimetric method for determining gold by $SnCl_2$ reduction which is useful in the 10-100 γ range.

MDDC - 373 Vanadium, Columbium, Tantalum (Analytical Chemistry Of The Manhattan Project), by S. W. Rasmussen, C. J. Rodden. 16p.

Volumetric, spectrophotometric, and spectrographic methods for determining vanadium are discussed, as is a gravimetric control method for columbium or tantalum in alloys with uranium.

MDDC - 374 Boron (Analytical Chemistry of The Manhattan Project), by M. S. Richmond, R. E. Telford. 29p.

This paper reports several methods for determining the presence of boron. Methods are given for the volumetric determination of boron using mannite as well as a colorimetric method using turmeric for the determination of microgram amounts of boron, separation by distillation from phosphoric acid, separation by Southerns distillation method, separation from $MgSO_4$ by ethanol extraction, separation by ether extraction, and direct determination in lime or dolomite.

MDDC 375 Steam Generating And Distribution Systems At Y-12, by E. S. Steinbach. 9p.

A brief description is given of the steam generating and distribution systems at Y-12.

MDDC - 376 Toxicity Following Inhalation (Chapter X-The Pharmacology And Toxicology Of Uranium Compounds. For Part II see MDDC - 330), by H. E. Stokinger, et al. 496p.

The purpose of this account is to summarize the toxicologic data obtained from exposure of animals to the inhalation of uranium dusts. Presented also are specific recommendations for some simple measures for protection of the worker against dust hazards based on results of tests of respiratory protective devices. The information is presented in a technical manner and is intended to be of service to toxicologists, medico-legal practitioners, plant supervisors, industrial hygienists, plant physicians and technicians, and engineers concerned with the safety of personnel who handle uranium dusts.

The report is broadly divided into procedures (Sections 1 and 2), presentation of results of short-term exposure studies (Section 3), results of respirator tests (Section 4), and a discussion of the significance of the results (Section 5). The uranium dusts studied include the hexafluoride, fluoride, nitrate, tetrachloride, tetrafluoride, dioxide, trioxide, peroxide, triuraniumoctoxide, "hi-grade" ore, and sodium and ammonium diuranate.

Because of the extensive nature of the work, complete data of all experiments are not included under the various experiments. Hence, certain characteristic results of the toxicologic response by inhalation have been selected.

MDDC 377 **The Handling Of Radioactive Materials In The Experimental Biology Section, by P. C. Tompkins, A. Broido, J. D. Teresi. 49p.**

This paper describes some of the developments in the handling of radioactive materials which have resulted from two years' work in the "semi-hot" laboratory of the Experimental Biology Section, at Argonne National Laboratories.

At first it was necessary to separate and purify fission products, but as purified radioactive isotopes became available, the operations were reduced to the withdrawal of aliquots of stock solutions and the preparation of these aliquots for use in the section. Since preparations were diversified, it was not feasible to develop a special apparatus for each preparation.

The laboratory resembles a standard chemical laboratory except for a concrete hood and a concrete storage cave. Disadvantages in the design of the laboratory have been found by experience.

The primary objective of the development program was to make it possible to do the necessary work without permitting overexposure to the operator. Surveys were made and indicated that it is never good practice to expose any part of the body to an unshielded beta source at any time and that the usual working position of the hands (directly over the sample) was the worst possible place of approach. Many of the problems were solved by the development of special equipment. Individual close-fitting shields, special glassware, and manipulative equipment were designed, and Lucite or polystyrene replaced lead for most shielding purposes. Rules for work in the laboratory were developed. Tongs and clamps used in the laboratory include, besides common tongs and slightly modified tongs, specially designed beaker tongs, handling tongs, pipette wiping tongs, stopcock turner, tube holder, stirring rod holder, and clamp holder.

A pantograph manipulator was designed which gave motion in three directions and to which could be attached pipettes or tongs. With a pipette inserted in the head of the manipulator, pipetting can be controlled from the control end of the pantograph.

Storage equipment developed included a steel cylinder, a lead shield, and tongs for carrying the lead shield.

Transparent plastic shields were developed for glassware such as volumetric flasks, graduated cylinders, and serum bottles. Special glassware used included a dispensing burette, a mixing cylinder assembly, and a Stang precipitator assembly. A shielded evaporator was designed.

A Ce^{144}-Pr^{144} solution of activity greater than 100 mc was prepared using much of the special equipment with a negligible exposure to the operator.

MDDC - 378 Elementary Pile Theory, by S. K. Allison. 31p.

A general, mathematical presentation.

MDDC - 379 Thermocouple-Type Hot-Wire Flowmeter, by J. W. Anderson, S. E. Bakes, I. B. Johns. 8p.

The thermocouple-type hot-wire flowmeter is a meter suited for measuring the flow of gases, both corrosive and non-corrosive. A constant current is passed through a 12-mil platinum heater wire which is perpendicular to the gas stream. A gold-palladium, platinum-rhodium thermocouple is spot-welded to the heater wire. An orifice plate is placed in the line ahead of the wires, and is lined up so that the gas passing through it is directed over the thermocouple heater wire junction. The meter was primarily designed to measure the flow of hydrogen fluoride; however, oxygen, hydrogen, nitrogen, and air have also been successfully measured. The meter is best adapted to measure small rates of flow (below 10 liters per minute); however, with slight modifications it can be adapted to larger flow.

MDDC - 380 Calculations on Countercurrent Electro-Migration, by G. Breit, F. L. Friedman. 37p.

The countercurrent electro-migration method has been found to give isotope separation in the case of potassium (MDDC-90) and chlorine. In the present report some diffusion problems of this method are treated mathematically. Formulas are given for the calculation of the concentration along the tube. Some typical numerical examples are worked so as to illustrate the use of the formulas and graphs showing the variation of concentration with time and distance.

MDDC - 381 Confirmation of Assignment of 2.6 h Ni to a Mass Number of 65, by E. E. Conn, A. R. Brosi, J. A. Swartout. 2p. (See also Physical Review, Vol. 70, p.768, November 1946)

The assignment of the 2.6 h Ni activity to a mass number of 65, which was recently reported on the basis of (n,p) reactions with copper samples of different isotopic abundances, has been independently confirmed using nickel preparations of various isotopic abundances.

Samples of NiO enriched in Ni^{62} and Ni^{64} were prepared with the calutron, purified, and analyzed mass-spectrographically. Comparisons were made of the relative amounts of 2.6 h beta activity produced during exposure to the neutron flux of the Clinton pile of a sample enriched in Ni^{62}, a sample enriched in Ni^{64}, and nickel of natural isotopic abundance. As is shown in the table, the relative activities agree with the relative amounts of Ni^{64} bombarded.

Evidence for Production of 2.6 h Ni by the Reaction: Ni^{64} (n, γ) Ni^{65}

	Natural Ni	Enriched Ni^{64}	Enriched Ni^{62}
Weight of Sample Bombarded (mg)	2.7	3.1	20
Percentage of Ni^{64}	0.88	85.1 ± 1	$1.8 \begin{matrix} +0.2 \\ -1.8 \end{matrix}$
Percentage of Ni^{62}	3.8	$1.0 \begin{matrix} +.1 \\ -.2 \end{matrix}$	94.2 ± 0.2
2.6 h beta Activity (c/m/mg Ni at 100% geom.)	5.3×10^6	4.2×10^8	6.8×10^5
Specific Activity (c/m/mg Ni^{64} at 100% geom.)	6×10^8	5×10^8	4×10^7

Although the value for the specific activity from the enriched Ni^{62} sample is of low accuracy corresponding to the large uncertainty in the mass-spectrographic analysis for Ni^{64}, it is in agreement with the assignment to a mass number of 65.

MDDC - 382 Intensity Fluctuations of a Neutron Chain Reactor, by F. de Hoffmann. 12p.

The inherent causes of the intensity fluctuations of a neutron chain reactor are discussed. A simple mathematical treatment of the multiplication of sources by a chain reactor, including the effects of delayed neutrons, is presented. The simplified assumption that all neutrons are equally effective in sustaining the reaction leads to a formula for the fluctuations as measured by a counter with random statistical response. This formula is shown to involve the dispersion of neutrons emitted per fission and it is shown that the measurement of the fluctuations of a going chain reactor provide a means of measuring this quantity.

MDDC - 383 Theory of the Criticality of the Water Boiler and the Determination of the Number of Delayed Neutrons, by F. de Hoffmann. 20p.

Some theoretical calculations in connection with the measurement of absolute criticality of the homogeneous reactor are presented and a method for measuring the effective number of delayed neutrons in the reactor is proposed.

MDDC - 384 The Preparation of Thin Boron Films, by R. W. Dodson, H. Russell, Jr. 11p.

A method of preparing thin films of boron on tantalum and tungsten foils has been developed. The films are made by the thermal decomposition of diborane at 800-1000°C. The mass of the films deposited on tungsten can be determined by weighing, with a probable error of ± 5 micrograms. These films are suitable for absolute neutron measurements, and have been used for that purpose.

MDDC - 385 Measurement of Neutron Fluxes in the Region 30 to 500 Kev With Proportional Counters, by D. H. Frisch. 17p.

Hydrogen-filled proportional counters were used to measure neutron fluxes from 500 Kev down to 27 Kev. The method gives reliable results at higher energies but not at lower energies. The method gives a lower limit on the flux at all energies.

MDDC - 386 Isotopic Assignment of Cd and Ag Activities, by A. C. Helmholz. 3p. (See also Physical Review, Vol. 70, p.982, December 1946)

100 mg samples enriched in Cd^{106} and Cd^{108} were prepared. Mass spectrographic analysis showed the former to be 58.3% Cd^{106}, 0.6% Cd^{108}, and the latter to be 0.7% Cd^{106}, 45.4% Cd^{108}. The remaining percentages of each sample contained the other Cd isotopes in approximately their normal ratio. These samples were bombarded with slow neutrons from the 60" cyclotron. The 6.7 hr-period was the predominant activity in the 106 sample after a few hours bombardment. A three-week bombardment produced in the 108 sample a weak, long-lived activity with absorption curve characteristic of the 158-day Cd. These two activities are easily identified by absorption curves of their electrons since the only electrons emitted (except for the rare positrons found by Bradt, et al.) are the conversion lines with range about 10 mg/cm^2. The results then assign the 6.7-hr Cd to Cd^{107}, the 93-Kev isomer to Ag^{107}; the 158-day Cd to Cd^{109}, and the 87-Kev isomer to Ag^{109}. A deuteron bombardment of normal Ag showed that the Cd isotopes are formed in roughly equal numbers, as would be expected from the roughly equal abundances of the Ag isotopes. The Cd^{109} assignment was further checked in the following way. If Ag is bombarded with α particles, Cd^{107} is formed only by the reaction (α,p3n), while Cd^{109} is formed both by this reaction and the more probable (α,pn). Bombardment of Ag with approximately 40 Mev α particles produced a good yield of the long-lived Cd, a small or possibly zero yield of the 6.7 hr Cd.

The bombardment of Ag with approximately 20 Mev deuterons also produced in the surface layers of the target a Pd activity of 13 hr half-life. An absorption measurement gave 1.0 Mev as the upper limit of the β spectrum, in satisfactory agreement with the 1.08 Mev reported by Kraus and Cork. The threshold of the reaction is $E_{max} + 2M_H - M_D$ or about 2.5 Mev. However, the low probability that protons be ejected through the barrier with low energy explains the fact that Krishnan with 9 Mev deuterons observed no Pd activity, and that the yield here was observable only at high bombarding energies. No other Pd activity was found. Pd^{107} must have a very short half-life to have escaped detection in other investigations, or a half-life greater than 25 years to be undetected in this case.

MDDC - 387 The Counting Method of Isotopic Analysis of Uranium, by D. E. Hull, B. Cohen. 50p.

Since the rates of α particle emission per unit weight of the various uranium isotopes are greatly different, this provides a basis for a method of isotopic analysis of uranium. It consists of counting, under definite geometrical and electrical conditions, the number of α particles emitted per unit time, from weighed quantities of uranium. The size and geometry of the sample required for accurate determination of the α activity of uranium is detailed, as well as the various corrections for thickness and counting losses.

Since one of the most important factors in attaining high accuracy in the counting of α particles from uranium was the preparation of the sample in a thin, uniform film, methods of electroplating thin films of uranium oxide on platinum were investigated. The composition of the electroplated film is not sufficiently constant to give the desired accuracy in measurements of specific activity when the film is weighed, $\pm$ 0.3% being about the limit of accuracy.

To avoid this difficulty, a quantitative plating method has been worked out which eliminates the need of weighing the films. The influence of various conditions on the rate of plating and the character of the deposit have been studied and optimum conditions for plating on platinum are given.

Experimental determinations of the effects of self-absorption of α particles in the film and of finite resolving time of the counter on the specific activity have been made.

The effects of various factors on the accuracy of the measurements with quantitative electroplated films are discussed. The conclusion is drawn, and is corroborated by experimental tests, that the probable error of the electroplating method is normally 0.05%. If 1,000,000 α particles are counted from such a film, the accuracy of the determination should be better than 0.1% probable error.

MDDC - 388 **A Manual On The Measurement Of Radioactivity, by A. H. Jaffey, T. P. Kohman, J. A. Crawford. 43p.**

An elementary instruction manual, written in 1943, on radioactivity measurements intended for persons unfamiliar with radioactive techniques. Included are general discussions of fundamental principles as well as descriptions of the various instruments used and the methods of sample preparation. Instruments described include the pulse ionization chamber, the magnet chamber, the air-screen low geometry chamber, the vacuum type low geometry chamber (Demultiplier), Geiger-Müller counters, the Lauritzen quartz fiber electroscope, and the ionization chamber with vacuum tube electrometer.

MDDC - 389 **Preparation of a Compact Radioyttrium Gamma-Ray Source, by M. Kahn. 5p.**

The actual preparation of a 400-m.c. gamma source, using the 105-day yttrium from a strontium target, is given in detail. The target is dissolved in dilute HCl. Paper mash is added to the resulting solution which is then made ammoniacal. The mash containing the yttrium is filtered and washed with dilute HCl. The washings which contain the carrier-free yttrium are then concentrated and evaporated to dryness.

MDDC - 390 The Preparation of Thin Films of Thorium Oxide, by M. Kahn. 11p.

A solution containing $Th(NO_3)4$ and a relatively small amount of $K_3Fe(CN)_6$ is electrolyzed. The deposited film on the cathode which is assumed to be $ThFe(Cn)_6$ is ignited to a mixture of iron and thorium oxides. The iron oxide is leached out of the composite film, leaving a thin ThO_2 film on the planinum disk. Films ranging from about 20 micrograms per square centimeter to 500 micrograms per square centimeter of ThO_2 have been reported.

MDDC - 391 Oxidation of Tracer Amounts of Plutonium by Perchloric Acid, by M. Kahn. 7p.

The rate of oxidation of plutonium from the 4^+ state to the 6^+ state[1] by a 70 per cent perchloric acid solution was studied as a function of temperature. The oxidation reaction was found to be essentially completed in 10 minutes at a temperature of 195°C. The presence of H_2SO_4 did not noticeably affect the rate of oxidation.

1 The existence of the 6^+ state was inferred by the plutonium not being carried by LaF_3.

MDDC - 392 Ionic Equilibria and Reaction Kinetics of Plutonium in Hydrochloric Acid Solution, by M. Kasha, G. E. Sheline. 82p.

The reaction 3 Pu(IV) = 2PU(III) + Pu(VI) has been studied in solutions of hydrochloric acid varying from 0.183 M to 1.545 M. In case of the forward reaction (disproportionation), the studies have been carried out at temperatures from 25°C to 70°C, whereas the back reaction (reproportionation), has been investigated at 25°C only. Measurements of both rates of reaction and equilibrium concentrations have been made. At 25°C the disproportionation constant $K = \frac{[Pu(III)]^2 [Pu(VI)]}{[Pu(IV)]^3}$ ranged from ~ 1×10^{-4} in 1.545 M hydrochloric acid to 6.9 in 0.183 M hydrochloric acid. Raising the temperature to 70°C increased this constant by a factor of 300 to 4000 depending upon the acidity. Without making corrections for ionic strength and chloride complexing effects, K was found to vary inversely as about the fifth power of the hydrochloric acid concentration. The rate of disproportionation at 25°C is inversely proportional to about the second or third power of the Pu(IV) concentration. The rate of reproportionation is greater at higher acidities and at higher concentrations of Pu(III) and Pu(VI). Thermodynamic calculations give the following data for the disproportionation at 25°C: ΔH^o = 41,000 cal/mole, ΔF^o = 3,300 cal/mole, ΔS^o = 127 E. U. The entropy of Pu(IV) is approximately -83 E. U.

MDDC - 393 Radiocolloidal Behavior of Neptunium and Plutonium; Adsorption of Plutonium (IV) at Trace Concentrations onto Glass, by E. L. King. 18p.

It has been found that plutonium (IV) at low acidity and at trace concentrations forms "radiocolloids." This has been demonstrated by centrifuging experiments in which it was found that the plutonium (IV) tracer was carried to the bottom of the cone at hydrogen ion concentrations less than approximately 0.01 M.

Neptunium (V) did not exhibit radiocolloid behavior even at 10^{-4} M H^+. The adsorption of plutonium (IV) at trace concentrations by glass was studied as a function of the hydrogen ion concentration. The adsorption increases as the hydrogen ion concentration is decreased.

MDDC - 396 A Survey Meter for the Measurement of Alpha, Beta, and Gamma Rays, Fast and Slow Neutrons, by O. G. Landsverk. 14p.

A quartz fibre electrometer type of survey meter is described in detail which, with accessory chambers, will measure all the major radiation types. Therefore, for special jobs where any or all types of radiation may be encountered, it is not necessary to transport a battery of specialized meters. On the other hand, where extensive surveys of known types of radiation are to be made, the special meters are more convenient and more efficient.

The meter will measure radiations in all ranges of intensity from cosmic ray and natural radioactive background to about ten roentgens per hour equivalent. A small laboratory could, therefore, get along very well with this one meter.

Where the rate of radiation is very low a counter will demonstrate that there is radiation present much more quickly. When the rate varies, a counter may be able to detect the presence of such variation, whereas the ionization chamber is not well suited for such use. However, for accurate determination of very low rates there is probably little to choose between them since neither can operate much below the cosmic ray and radioactive background level and both require the use of a stop watch over an extended period in order to avoid statistical errors. The required time for a determination within a certain limit of accuracy may, in some cases, be somewhat shorter in the case of the counter.

A quartz fibre portable instrument of this type is very dependable because of the simplicity of the indicating device, because of its shock-proof and generally fool-proof characteristics and because of its ability to resist the effect of high humidity.

The meter has a very stable calibration. In this connection it should be noted that this refers to the voltage sensitivity of the electrometer, not the current sensitivity of the chambers. The gamma-beta, alpha, and slow neutron chambers, since they are open to the air, change in sensitivity with the density of the air. The variation is normally small but may, under adverse conditions of air temperature and pressure, amount to more than 10%. Since the gamma rays have no definite range and only a small percentage of their energy is absorbed in the chamber, the gamma-ray chamber changes sensitivity directly as the air density. The gas laws may then be used to correct quite accurately for changes in air temperature and pressure.

In beta-and alpha-ray measurements the situation is more complicated. The chambers are so designed that there are compensating effects and the dependence of the chamber sensitivity on air density is probably small except in cases where the energy of the particles is either very large or very small. The design is such as to count the particles one for one rather than to measure their integrated energy. However, the ability of an ionization chamber to do this is limited to a band of energies. No one chamber is independent of the energy of the particles over the entire spectrum.

MDDC - 394 The Fission Cross Section of Np^{237}, by E. D. Klema. 7p.

The cross section for fission of isotope Np^{237} has been measured for neutrons of energies from near thermal to 3 Mev by counting simultaneously the fissions from known Np^{237} and U^{235} foils placed back to back in a monoenergetic neutron beam. No fission was detected with near-thermal neutrons. The threshold energy is about 350 Kev, the cross section rising to a constant value of about 1.45 barns from 1.1 Mev to 3 Mev. The absolute values of the cross sections given depend on the values of σ_f U^{235} and on the mass of Np^{237}.

MDDC - 395 New Models of Integrating Gamma-Ray and Slow Neutron Pocket Meters (Dosimeters) and Pocket Chambers, by O. G. Landsverk. 9p.

Two new models of integrating gamma-ray quartz fibre electrometer type of pocket meters have been assembled and tested. They have ranges of one and ten roentgens for full scale. The ten roentgen model has also been adapted to the measurement of slow neutron dosage. These types have each been produced in quantities of one to several dozen and have been quite thoroughly field-tested.

A slow neutron pocket chamber for use with a Victoreen minometer is in small scale production. It has been laboratory-tested, but has not as yet been given adequate field tests.

The characteristics of the following instruments are described in detail:

(a) The standard L-W gamma-ray integrating pocket meter
(b) A 0-1.0 r gamma-ray integrating pocket meter
(c) A 0-10 r gamma-ray integrating pocket meter
(d) A slow neutron integrating pocket meter
(e) A slow neutron integrating pocket chamber

MDDC - 397 **Fluorination and Atomic Energy, by E. T. McBee. 2p.**

This paper briefly summarizes the research activities of chemists at Purdue University in developing fluorocarbons needed by the Manhattan Project.

MDDC - 398 **Daniels Atomic Power Plant, by C. R. McCullough, E. E. Hawk. 1p.**

A schematic drawing of the Daniels Atomic Power Plant.

MDDC - 399 On the Milne Problem for a Large Plane Slab with Constant Source and Anisotropic Scattering, by R. E. Marshak. 9p. (See also Physical Review, Vol. 72, p.47, July 1, 1947.)

Formulae are derived for the asymptotic neutron density and the current emerging from an infinite plane slab (thickness large compared to the mean free path) which sustains a uniform production of neutrons. The slab is assumed to be weakly capturing and to scatter neutrons in accordance with the law: $(1/4\pi)(1+3f_1\mu)$ where f_1 is a constant, μ is the cosine of the angle of scattering. Expressions for the asymptotic neutron density in the slab and the emerging current in the limiting cases $f_1=0$ and/or no capture are given.

MDDC - 400 Beta and Gamma Ray Energies of Several Radioactive Isotopes, by L. C. Miller, L. F. Curtiss. 2p. (See also Physical Review, Vol. 70, p.983, December 1946.)

The thin magnetic lens spectrometer constructed by Wilkinson and Rall was used to obtain data on the beta and gamma ray energies of several additional radioactive isotopes.

All activities were produced by slow neutron irradiation of the elements of their compounds in the Clinton pile. All samples, with the exception of the dysprosium compounds, were spectroscopically analyzed for impurities. In no cases did the combination of factors, such as amount of impurity, cross section of impurity for slow neutron capture, and period of any activity due to the impurity, appear to be such that the impurity could be responsible for any observed; gamma rays.

A table is given which summarizes the results obtained; included are isotopes of As, W, Ga, Cr, Ra, Hg, La, Sm, Sb, Ge, Mo, and Dy.

MDDC - 401 Review of Water Monitoring Procedures at Clinton Laboratories, by H. M. Parker. 11p.

The water monitoring procedures at Clinton Laboratories are reviewed from the standpoint of measurement of β ray dose, experimental standard, correction to the "tolerance water," measurement of gamma-ray dose, relation of β and γ activity, hazard of ingestion relative to external radiation, disposition of activity after release from the holdup ponds, preliminary suggestions for revised procedures, β ray dosage, and gamma-ray dosage.

Calculations and equations are given for determining the standards that have been established.

MDDC - 402 The Cyclotron in the Atomic Energy Developments. by I. Perlman. 11p. (See also Chemical Engineering News, Vol. 24, p. 3032-3035, November 1946)

A review dealing with the use of cyclotrons for the preparation of pilot plant amounts of fissionable materials. Other applications of cyclotrons to nuclear research are also briefly discussed.

MDDC - 403 Water Problems in the Industrial Application of the Utilization of Atomic Energy, by I. Perlman. 7p.

In the pile areas at Hanford a large fraction of the installations are concerned solely with the pumping and treatment of the water that is sent through the piles and eventually back to the river. The amount of water pumped would take care of the needs of a large city. In view of the necessity of providing emergency stand-by equipment and elaborate safety controls, the entire water system is extremely complex but nevertheless its careful design has allowed trouble-free operation.

In considering water as a coolant it was necessary to examine its neutron absorption. Fortunately hydrogen falls in the class of substances with rather low affinity for neutrons and oxygen is even far better in this regard. Nevertheless, it was of importance to restrict to a minimum the amount of water that is present in the pile at any one time. This restriction entails fast water flow rates through relatively small annuli surrounding the uranium slugs, which in turn necessitates the provision of water pumping system operating at relatively high pressures. The use of water in a neutron chain reactor or pile posed some entirely new problems to the engineers. One of these is the problem of corrosion which in itself is not new, but the premium attached to trouble-free operation in this particular plant make it extremely important that no difficulties be encountered from this source.

The canning problem is briefly reviewed, as is the problem of induced radioactivity in water.

MDDC - 404 Mass Spectrographic Confirmation of the Isotopic Assignment for the Long-lived Radioactivity in Beryllium, by A. K. Pierce, F. W. Brown III. 2p. (See also Physical Review, Vol. 70, p. 779, November 1946)

This mass assignment has been confirmed by observing the activity of samples separated by a mass spectrograph.

This material used was part of sample which had been activated and purified in 1940. This material was in the form of BeO; it was mixed with powdered charcoal, heated to 600° - 700°C, and chlorine gas passed over it to generate $BeCl_2$ vapor, which was carried into the ion source arc by the gas stream. The measurements on samples collected at the mass 9 and mass 10 positions were:

Be^9

Weight of Be collected =	9.8 ± 0.3 mg.
Counting rate =	20.3 ± 0.7 counts/min
Background =	21.6 ± 0.4 counts/min
Activity =	-1.3 ± 0.8 counts/min

Be^{10}

Counting rate =	62.2 ± 0.9 counts/min
Background =	21.6 ± 0.4 counts/min
Activity =	44.6 ± 1.0 counts/ min

From counts of the original BeO sample under the same counting conditions the expected counting rate for the collected Be^{10} sample should be 56.5 ± 2.4 counts/min if all the activity were due to Be^{10}. Therefore, the β activity is ascribed to Be^{10}.

MDDC - 405

Slow Neutron Velocity Spectrometer Studies I: Cd, Ag, Sb, Ir, Mn, by W. W. Havens, C. S. Wu, J. R. Dunning, L. J. Rainwater. 41p. (See also Physical Review, Vol. 71, p. 65-79 January 15, 1947.)

The Columbia Neutron Velocity Spectrometer has been completely redesigned and enlarged to permit 32 separate measurements to be made simultaneously with greatly improved resolutions and precision.

A detailed comparison between the experimentally measured cross section of Cd and the Breit-Wigner one-level formula gives excellent agreement for over a factor of 100 in energy and 1000 in cross section. The selected parameters are σ_o (7200 $\pm$ 200) E_ρ = (0.176 $\pm$ 0.002) ev , and Γ = (0.115 $\pm$ 0.002) ev with a value of (5.3 $\pm$ 0.7) added as a "constant" term in the total cross section. (Energy is in ev and cross sections in units of $\times 10^{-24}$ cm^2/atom.)

The silver resonance levels have been remeasured with essential agreement with the previous results. Three levels are well defined at (5.1 $\pm$ 0.1) ev, (16 $\pm$ 1) ev, and (45 $\pm$ 4) ev.

Antimony has also been checked and the upper "level" has been partially resolved into two levels at (15 $\pm$ 1) ev and (21 $\pm$ 1.5) ev. The other level is at (5.8 $\pm$ 0.15) ev and there is no indication of higher energy levels.

Manganese is found to have a strong level at (300 $\pm$ 40) ev and probably other unresolved higher energy levels. There is no indication of levels at lower energies where the cross section shows a normal 1/v type absorption with σ = [(2.2 $\pm$ 0.4) + (2.24 $\pm$ 0.05) $E^{1/2}$].

The iridium curve shows high detail. This includes strong levels at (0.64 $\pm$ 0.015) ev, (1.27 $\pm$ 0.04) ev, (5.2 $\pm$ 0.2) ev, and (8.7 $\pm$ 0.3) ev. There is a low broad transmission dip for energies above about 20 ev indicating several more levels may be present. A 1/v type absorption is observed in the thermal region with σ = [(14 $\pm$ 6) + (64 $\pm$ 2) $E^{-1/2}$].

Further analysis has been made for most of the resonances.

MDDC - 406 The X-Ray Spectra of the Last-Row Elements, by H. Russell, Jr.

X-ray energy level diagrams as given in the literature are tabulated for radium, thorium, and uranium. A level scheme for protoactinium is derived from the published data. After a brief review of the use of X-ray data in studying outer electronic structure, it is pointed out that differences in the X-ray spectra should exist depending on whether the outer electrons are in f or d orbitals. The observed separation of the O_I and O_{II} levels in thorium and uranium indicates that the f levels lie lower than the d. This hypothesis also provides a reasonable explanation for the observed differences between the M_{IV} and M_V absorption edges and the M_{IV} and M_V levels calculated from the omission spectra and the L_{III} edge.

MDDC - 407 The Carrier-Distillation Method for Spectrographic Analysis and Its Application to the Analysis of Uranium-Base Materials, by B. F. Scribner, H. R. Mullin. 33p. (See also Journal of Research of the National Bureau of Standards, Vol. 37, p. 379-389, December 1946)

A method of fractional distillation in the d -c arc was developed for the spectrographic determination of 33 volatile impurity elements at concentrations as low as a fraction of a part per million in uranium-base materials. The method involves (1) the conversion of the sample matrix to a form having low volatility, (2) the addition of a small amount of a selected volatile "carrier" material, and (3) partial distillation of the mixture in a d -c arc with an improved electrode design. In the analysis of uranium-base materials, the sample was converted to the oxide U_3O_8, and gallium oxide was added as a carrier (2 parts Ga_2O_3, 98 parts U_3O_8). The procedure was applied to the determination of Ag, Al, As, Au, B, Ba, Be, Bi, Cd, Co, Cr, Cs, Cu, Fe, Ge, Hg, In, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Rb, Sb, Si, Sn, Tl, V, and Zn. Repeated results for B, Cd, Si, Fe, Mg, and Mn, determined photometrically, agreed within $\pm$ 10%. The high sensitivity and general applicability of the method are due to the fact that the refractory sample matrix is not volatilized appreciably during the period that the minute quantities of impurity vapors are swept into the arc by the carrier.

MDDC - 408 Thermal Neutron Activation Cross Sections, by L. Seren, H. N. Friedlander, S. H. Turkel. 1p. (This is an abstract; for complete paper see MDDC-613).

A survey has been made of cross sections for those nuclei which give rise to radioactive isotopes upon thermal neutron capture. This survey covered 67 elements and cross sections for 133 of the known 160 induced activities. The smallest and largest atomic cross sections measured were 4×10^{-7} barns (10^{-24} cm^2) for the production of 31-second $_8O^{19}$ and 725 barns for the production of 140-minute $_{66}Dy^{165}$. The source of neutrons was the graphite pile and the heavy water pile at the Argonne laboratory. Incident neutron flux was measured by activated monitor which had previously been calibrated in a standard graphite pile. Captured neutron flux was measured by counting the absolute number of beta decay particles after irradiation, and reducing this decay rate to a saturated value.

MDDC - 409 An AC Operated Mattauch-Type Mass Spectrograph, by A. E. Shaw, W. Rall. 27p. (See also Review of Scientific Instruments, Vol. 18, p. 278-288, May 1947)

A mass spectrograph for chemical analysis of solid samples has been developed. The Mattauch arrangement of a 31° 50' electric deflection followed by a 90° deflection in a magnetic field was used in order to obtain a large mass range in focus on one plate. The accelerating and deflecting voltages and the current for the electromagnet were obtained from stabilized rectifier circuits connected to the 60-cycle AC supply. The electromagnet with 100 milliamperes gave a field of 18,800 gauss across a 1/8" gap. During the introduction of the plate or insertion of new electrodes a gate valve was closed to isolate the spectrograph from the pumping system. In this way different samples could be examined rapidly. The ion source was energized by a compact Tesla transformer wound on Lucite cylinders. One exposure covered a mass range from any mass M up to a mass 8M.

MDDC - 410 **A Rapid Separation of the Rare Earths Employing Ion-Exchange (I. Cerium and Yttrium), by F. H. Spedding et al. 27p.**

A rapid means of separating the rare earths using the ion-exchange resin Amberlite IR-1 is described. Separations of both tracer and macro amounts of Ce^{+++} and Y^{+++} from each other were obtained, with analyses being performed by using radioactive tracers. A column of the resin is prepared in the acid cycle and the rare earth ions are adsorbed. This requires only a small fraction of the total column. Desorption of the material is done by a citric acid-ammonium citrate solution. The separation is due to competition between two processes: the adsorption of the rare earth ions on the resin and the formation of rare earth-citrate complex ions. These processes are continuously repeated as the material is eluted from the column. Experiments are described in which tracer amounts of the two elements were studied separately and again in mixtures. Further experiments were carried out on a macro scale using larger columns. It is shown that the separation can be made very effective when such factors as pH of the citrate, column length, and composition of the starting material are considered.

MDDC - 411

A Rapid Separation of the Rare Earths Employing Ion-Exchange, II. Neodymium and Praseodymium, by F. H. Spedding et al. 40p. (See also Journal of the American Chemical Society, Vol. 69, p. 2786-2792, November 1947)

A systematic investigation has been conducted on the variables which control the separation of adjacent rare earths from a column of Amberlite IR-1 resin. The resin, acting as the absorbent, was used with the eluant, citric acid - ammonium citrate, to obtain separations of neodymium and praseodymium in macro amounts. Spectrophotometric and spectrographic analyses were used to show the extent of separation which changed markedly with changing conditions. The variables studied were pH, flow rate, length and diameter of the column, and the weight and composition of the starting sample. A set of optimum conditions are presented to be used when 5% citric acid is employed. Under these conditions, one pass through the column yields approximately 22% of the Nd with spectroscopic purity when the starting mixture contains equal amounts of Nd and Pr.

MDDC - 412

New Data Relating to the Separation of the Nitrogen Isotopes by Exchange Reaction between Ammonia and Solutions of Ammonium Nitrate, by H. C. Urey, I. Kirshenbaum, J. S. Smith. 16p. (See also Journal of Chemical Physics, Vol. 15, p. 440-446, July, 1947.)

The fractionation factor for the exchange reaction between ammonia and ammonium nitrate was determined as a function of the dissolved ammonia content. It was found that for a stock solution containing 59.3-59.6 percent ammonium nitrate

$$\alpha = -0.029\,M + 1.034$$

where α is the fractionation factor at 25°C and M the fraction (Moles NH_3)/(Moles NH_3 + Moles NH_4NO_3) in solution. From these data, the equilibrium constant for the exchange reaction

$$N^{14}H_4^+ (sol) + N^{15}H_3 (gas) \rightleftharpoons N^{15}H_4^+ (sol) + N^{14}H_3 (gas)$$

was calculated to be 1.034, while that for the reaction

$$N^{14}H_3 (sol) + N^{15}H_3 (gas) \rightleftharpoons N^{15}H_3 (sol) + N^{14}H_3 (gas)$$

was found to be 1.005. Vapor pressure and density data were determined for the ammonia-ammonium nitrate solutions as a function of the ammonia concentration. Corrosion of monel by the ammonia-ammonium nitrate solutions was measured.

MDDC - 413 **Magnet Test Curves, by Radiation Laboratory. 116 p.**

This document consists of magnet test curves for the University of California cyclotron.

MDDC - 414 **Absolute Calibration of a Ra-Be Neutron Source, by R. L. Walker. 56p.**

The number of neutrons from a half-gram Ra-Be source (No. 44) has been measured by a method proposed by O. R. Frisch. The measurement consists in finding the volume integral of the neutron absorption rate in a boric acid solution. This absorption rate is determined with the use of thin manganese and indium foils, standardized by means of a boron trifluoride counter. The ratio of the absorption cross sections of boron and hydrogen for thermal neutrons enters as a correction term in the determination of the source strength, (Q). This ratio was measured during the course of this experiment, and a value of 2270 obtained, as compared with 2380 found by H. Kubitschek at Chicago. The number of neutrons (Q) from source no. 44 was found to be 5.92×10^6 neutrons per second, with an estimated error of 5 per cent.

MDDC - 415 **The Structure of Uranium Hexafluoride as Determined by the Diffraction of Electrons on the Vapor, by S. H. Bauer. 38 p.**

The model for uranium hexafluoride which is in best agreement with the electron diffraction data is a slightly distorted octahedron with 3 U-F bond distances equal to 1.86 Å, and 3 U-F bond distances equal to 2.16 Å. Each set of three bonds forms a trigonal pyramid, the length of all the base edges being 2.88 Å. The fact that this model does not have a center of symmetry is not necessarily inconsistent with the fact that the molecule has no dipole moment large enough to be detectable. The short bonds may be considerably more ionic than the longer ones; indeed, some such postulate must be made in order to explain the non-equivalence of six bonds in UF_4. (Expected for a coordination number of 6, the configuration d^2sp^3 gives a symmetrical octahedron; d^3p^3 gives a trigonal antiprism with the possibility of two unequal sets of three bonds). That this difference in ionic character is enough to compensate for the longer U-F extensions on the opposite side of the molecule appears to be fortuitous. With regard to the Raman, infrared and thermodynamic arguments which favor a more symmetrical structure, it is stated that such conclusions are based on the absence of lines, which actually may be present but are not in a favorable region for observation. However, the discrepancy with the single crystal X-ray results is real. Two alternate explanations are offered.

1. The molecular structure in the solid differs from that in the vapor. One would expect the higher symmetry to occur in the vapor. The reverse is found.
2. The methods of analysis of the diffraction data are quite different for the two investigations. In the X-ray studies reliance is placed on the assumed phase assignments to permit carrying through the Fourier projection. This is followed by a statistical checking of individual spot intensities. In the electron diffraction studies chief reliance is placed in the radial distribution computations, and is followed by a check on diffraction intensities.

MDDC - 416 This is an abstract only. For complete paper see MDDC-515.

MDDC - 417 Complete Blueprints for duPont Carbon Fluorine Cell.

13 prints

MDDC - 418 The Effect of Age on the Radiosensitivity of Mice, by H. J. Curtis. 6p. March 28, 1946.

Mice of different ages ranging from 1.5 to 12 months were exposed to gamma rays in an effort to determine the change in radiosensitivity with age. The dose necessary to cause 50% killing was determined for each age group and sex. No change in sensitivity with age was observed with either sex, although the experimental error in the case of the males was quite large. The females were found to be more resistant than the males.

MDDC - 419 The Effect of Clay on the Intestinal Absorption of Strontium, by H. J. Curtis. 8p.

Rats have been fed active strontium which was adsorbed on clay, while their controls were fed the same amount of active strontium in aqueous solution. There was no significant difference in the amount deposited in the skeleton between the two groups, and it is concluded that if ions are adsorbed on inert material, they will be eluted during their passage through the gastro-intestinal tract.

MDDC - 420 **Tracer Studies With Inhaled 1.0 Year Ruthenium**, by M. Dailey, I. Wender, R. Abrams. 23p.

This paper deals primarily with the fate of tracer quantities of airborne ruthenium after inhalation by rats.

1. In the course of the work it was necessary to have a simple, quantitative test for Ru, and a colorimetric test was developed which depends on the blue color formed with rubeanic acid. It was possible to detect 2 μg of Ru with 10 per cent accuracy.

2. In order to expose animals to RuO_4 vapor, a generator was needed which would supply RuO_4 at a continuous and more or less uniform rate. Of a number of oxidizing agents investigated for this purpose, potassium permanganate in sulfuric acid was best suited.

3. A rough determination was made of the chemical toxicity of Ru for mice. By intracardiac injection, doses in the range of 3μg/g were acutely toxic.

4. Methods have been developed for assaying tissues for radioactive ruthenium. The hard β of the 1.0 year Ru - 30 sec Rh system was counted. To avoid volatility losses, small tissues were minced, dried at 110°, and counted. Larger tissues were muffled and a correction made for losses due to volatility.

5. Three types of Ru exposure were carried out--to RuO_4 vapor, dry "$RuCl_3$" (In) aerosol, and "$RuCl_3$" solution. In all cases the Ru was rapidly passed from the lungs and rapidly excreted via the urine and feces. The kidney tends to retain a considerably higher concentration than other tissues. The rapid excretion, approximately 90 per cent in 30 days, minimizes the hazard resulting from internally deposited Ru.

MDDC - 421 This is an abstract only. For complete report see MDDC-520.

MDDC - 422 The Chemistry of Uranium Compounds(Chapter I. Pharmacology and Toxicology of Uranium Compounds), by A. L. Dounce, J. F. Flagg. 153p.

The preparation and properties of some uranium compounds important in toxicological work are given. They include the tetrachloride, tetrafluoride, dioxide, hexafluoride, trioxide, tetraoxide, tritaoctoxide, acetate, fluoride, and nitrate. An outline of the aspects of the chemistry of uranium compounds which apply to biochemical and toxicological studies is also included. This outline includes the following topics:

(a) The chemistry of hexavalent uranium with particular reference to the formation of complexes with various materials in solution.

(b) A brief description of the chemistry of tetravalent uranium with particular regard to a comparison of its chemistry with the chemistry of U_6.

(c) A study of the oxidation-reduction properties of the hexavalent-tetravalent uranium system, with particular regard to the effect of complexers, pH, and the role of pentavalent uranium.

(d) Dissociation constants of various acetate complexes of U_6 and U_4.

(e) The problem of polymerization of uranium compounds in solution.

MDDC - 423 The Action of Uranium on Enzymes and Proteins(Chapter XIII Pharmacology and Toxicology of Uranium Compounds), by A. L. Dounce, Tien Ho Lan. 259 p.

Uranium compounds fall under the general classification of heavy metal compounds, many of which are known to act as poisons when administered in relatively small doses. Such compounds are immediately suspected of interfering with the catalytic machinery of cells, both because of the smallness of the toxic doses, and because in vitro experiments have shown that many of them act as protein precipitants and denaturants, as well as enzyme poisons. From these considerations it was thought desirable at the outset of the work with uranium to find out how it behaved towards various isolated enzymes and proteins and to compare its behavior in these respects to the corresponding behavior of other heavy metals. This was particularly desirable at the time when it was not quite clear that the primary action of low doses of uranium is to damage the kidney tubules. It was felt that if, for example, a particular enzyme or enzyme system could be found which was especially sensitive to uranium compounds, it might be possible to make some prediction about the chronic action of uranium and perhaps to find therapeutic agents for uranium poisoning.

A further consideration which encouraged the continuance of enzyme and protein work was the thought that plasma proteins must be importantly concerned in the transport of uranium in the blood stream.

As a result of the work on the action of uranium compounds on enzymes and proteins it can be stated that hexavalent uranium (the valence form which is of chief concern in the animal body) probably is not a specific enzyme poison under

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MDDC - 423 The Action of Uranium on Enzymes and Proteins(Chapter XIII Pharmacology and Toxicology of Uranium Compounds), by A. L. Dounce, Tien Ho Lan. 259p. (cont'd from page 246).

physiological conditions in the sense that arsenic or mercury are specific poisons for sulfhydryl enzymes. Hexavalent uranium shows a strong tendency to form very slightly dissociated complexes under physiological conditions, for instance with organic acids and bicarbonate. Since these complexes apparently do not affect enzymes, uranium probably is not a particularly powerful enzyme poison in the animal body except in special locations such as the kidney tubules where the resorption of bicarbonate and drop in pH allows sufficient UO_2^{++} to accumulate to permit a combination of U_6 with enzymes and cell proteins.

It is apparently the UO_2^{++} ions which combine with proteins and inhibit enzymes. It has been found that in all cases so far studied, the inhibitory action of hexavalent uranium on isolated enzymes or enzyme systems increases very sharply as the pH decreases, apparently because of liberation of UO_2^{++} from complexes. This point is illustrated in a series of experiments. A detailed discussion of the chemistry of complexes of U_6 is also included. In regard to the combination of hexavalent uranium with proteins, it can be stated definitely that it combines rather firmly with acid groups of proteins and that it probably can combine only in loose ionic or salt type linkages with basic groups. Sulfhydryl groups do not combine with U_6. U_6 has a very slight or unmeasurable effect in denaturing proteins at a pH range from 6 to 8.

The combination of U_6 with proteins is sufficiently firm so that some strong complexer such as bicarbonate, citrate, or malate must be used to reverse the combination. The presence of even a small amount of combined U_6 destroys the crystallizability of egg albumin, but crystallizability can be restored by prolonged dialysis with repeated additions of a strong complexer. The presence of a small amount of U_6 also affects the mobility of plasma proteins in the Tiselius electrophoresis cell.

In regard to the problem of transport in the blood stream, it can be stated that U_6 is chiefly combined with bicarbonate but also partly with plasma proteins. The lower the plasma bicarbonate content, the more U_6 is carried by protein. There is less quantitative work on U_4 than on U_6, since it has been felt that in case of lung exposure to U_4 the material entering the plasma would be U_6 rather than U_4. Work on the oxidation-reduction problem has made it fairly clear that the chemistry of uranium in the animal body is chiefly the chemistry of U_6 for all modes of entry of uranium except by direct injection. By the latter method U_4 can of course be introduced into the body.

It has been found that in general, U_4 appears to have a somewhat greater affinity for protein than has U_6 and that it is usually a somewhat more severe enzyme poison than is U_6. The latter point is difficult to prove however, since the U_4 might contain small amounts of impurity in the form of other heavy metals which are absent in U_6 compounds. The use of U_4 in enzyme poisoning experiments is hampered by the insolubility of U_4 at pH values in the neighborhood of 7.0 where most enzyme reactions are carried out.

U_4 has somewhat less tendency to form complexes with bicarbonate than does U_6 and because of this and its apparently greater affinity for protein, it must be carried in the blood stream to a considerable extent in the form of complexes with blood protein after being injected. However, it is also possible that some U_4 is carried as colloidal oxide stabilized by plasma protein. These statements are born out by excretion studies.

MDDC - 424 This is an abstract only. For complete report see MDDC-774.

MDDC - 425 The Rate of Ion Production by an Electron Beam, by T. L. Hill, L. H. Aller. 11p.

It is shown how one may calculate approximately the rate at which ions are produced by electrons passing through a gas in those cases where it cannot be safely assumed that the ion current produced is simply proportional to (a) the gas density, (b) the ionization cross-section, (c) the path length, and (d) the electron current. This situation arises when one or more of (a), (c), and (d), above, becomes sufficiently large.

MDDC - 426 The Structure of Crystalline Rubidium Uranyl Nitrate, by J. L. Hoard, J. D. Stroupe. 37p.

X-ray, optical, and goniometric data are consistent with the assignment of crystalline rubidium uranyl nitrate, $RbUO_2(NO_3)_3$, to the hexagonal system (rhombohedral division). The fundamental lattice is rhombohedral; the primitive rhombohedron having $\underline{a}$ = 8.30 A, $\underline{\alpha}$ = 68°42 , contains two stoichiometric molecules. The corresponding six-molecule hexagonal unit has $\underline{a}$ = 9.36, $\underline{c}$ = 13.88 A. Both rubidium and uranium atoms must lie on the three-fold axes. Application of lattice theory in rigorous form would require the uranyl ion as a whole to lie on a three-fold axis and thus have a linear configuration.

The X-ray intensity data show conclusively that both uranium and rubidium lie on body-centered rhombohedral lattices; the data indicate, moreover, that the origins of the two lattices are separated by exactly $\underline{c}/4$ along the unique axis. The X-ray symmetry is that of the point-group D_{3d}, and no reflections [hh l], l odd (or [NO·L] , L odd) are observed. A sensitive test for pyroelectricity was negative. The only space-group requiring all of these data is D^6_{3d} - R3c; an atomic arrangement based upon D^6_{3d} is found to account satisfactorily for both X-ray and optical data.

The atomic positions within the hexagonal unit of structure are 6U in 6(a); $6Rb^+$ in 6(b); 12 O of UO_2^{++} in 12(c); 18 N in 18 (e); 180_I of NO_3^- in 18(e); 360_{II} of NO_3^- in 36(f). This assignment is initially unique except for the distribution of uranium and rubidium between the no-parameter positions (a) and (b).

The structure has six variable parameters; these are reduced to three by using the well-established dimensions of the nitrate ion. One parameter determines the positions of the centers of nitrate ions on the two-fold axes, a second fixes the orientation of the groups with respect to (00.1), and the third parameter determines the uranium-oxygen bond distance in uranyl ion. This bond distance was estimated as 1.58 A, on the basis of Bauer's work and known covalent radii.

The large observed difference between the principle indices of refraction, $\omega - \epsilon$ = 0.169, requires that the nitrate ions be nearly or exactly in flat layers perpendicular to the three-fold axis of the crystal. These data are accounted for semi-quantitatively if, in addition, nearly or exactly linear uranyl ions are extended along the three-fold axes.

As reflections [HK·L] , L odd, arises only from the scattering of nitrate groups they can be used to complete the determination of the variable parameters for these anions. The detailed atomic arrangement in crystalline rubidium uranyl nitrate is shown for which nitrate groups lie exactly in plane layers spaced c/6 apart. Centers of the anions (nitrogen atoms) occupy the positions 1/3 0; 0 1/3; 2/3 2/3, and 2/3 0; 0 2/3; 1/3 1/3, respectively in alternate layers perpendicular to the unique crystal axis. Uranium atoms and nitrate ions lie in the planes z = 1/12, 1/4, 5/12, 7/12, 3/4, 11/12, rubidium ions and uranyl oxygen atoms in the planes z = 0, 1/6, 1/3, 1/2, 2/3, 5/6. Each rubidium ion is equidistant from twelve nitrate and two uranyl oxygen atoms all at 3.14 A, each uranyl oxygen is equidistant from twelve nitrate oxygen atoms, also at 3.14 A, each uranium is equidistant from six nitrate oxygen atoms at 2.72 A, and all O-O contacts between neighboring nitrate groups are greater than 3.2 A.

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MDDC - 426 The Structure of Crystalline Rubidium Uranyl Nitrate, by J. L. Hoard, J. D. Stroupe. 37p. (cont'd from page 249).

If the uranyl ion is linear, as indicated by the most direct interpretation of the data, and the bond distance is close to the estimated value, 1.58 A, there is probably no appreciable shift from the ideal positions shown. Even if the bond distance is materially changed and the uranyl ion is appreciably "kinked" changes in nitrate parameters must be small.

The uranyl oxygen atoms are "caged" by nitrate oxygen in a manner which shows shows that appreciable kinking of the uranyl ion is very improbable. The dimensional relations indicate that a bond angle, O-U-O, as small as 150^{o} is quite unlikely. The resultant force exerted on a bent uranyl ion by its environment is large and tends to straighten it out. All of the pertinent data indicate that in this crystal the uranyl ion is substantially linear.

The structure indicates also that a charge of at least two protonic units is associated with the uranium atom of uranyl ion.

MDDC - 427 The Structure of Crystalline Uranium Hexafluoride, by J. L. Hoard, J. D. Stroupe. 44p.

Crystalline uranium hexafluoride in the form of cylindrical single crystals sealed within thin-walled capillary tubes were studied by x-ray diffraction and optical methods. Analysis of the data has led to a complete determination of the structure of the crystal at 25^{o}C.

The orthorhombic unit of structure has $\underline{a}$ = 9.900, $\underline{b}$ = 8.962, $\underline{c}$ = 5.207 Å, space-group D_{2h}^{16} - Pnma, and contains four molecules of uranium hexafluoride. The calculated density is 5.06 g/cc at 25^{o}C. To a good first approximation the structure is based upon closest-packing of fluorine atoms and contains nearly regular octahedral UF_6 molecules. Uranium atoms occupy the positions 4(c) in the mirror planes of D_{2h}^{16} with the parameters $\underline{x}$ = 0.1295 $\pm$ 0.0005, $\underline{z}$ = 0.081 $\pm$ 0.001. Modified Fourier analysis of the (hk0) and(h0l) data lead to the positions for fluorine atoms that are tabulated.

The configuration of the UF_6 molecule in the crystal is seemingly not quite regular although the indicated variations may be within the accuracy of the determination. It seems rather more certain that the molecular configuration within the crystal is not compatible with that derived by Bauer for molecules of the vapor.

The structure found for the crystal is discussed also in connection with other physical data which have been reported for crystalline uranium hexafluoride.

MDDC - 428 **Some Neutron Induced Activities in the Rare Earths, by M. G. Inghram, R. J. Hayden. 1 p. (See also Physical Review, Vol. 71, p. 144, January 15, 1947)**

Nitric acid solutions of samarium, europium, holmium, and ytterbium were subjected to neutron bombardment in the Argonne heavy water pile. Half-life and absorption data were obtained with standard counting equipment. Masses of certain activities were obtained by use of the mass spectrograph. Using these techniques, the 46 hr. Sm activity was shown to result from an isotope of mass 153, the 9.2 hr. Eu activity from an isotope of mass 152 and the 27 hr. Ho previously given as 35 hrs. from a mass of 166. The long-lived activity in Eu was shown to result from two isotopes, the previously reported 154 and a new, long-lived 152 isomeric with the 9.2 hr. Eu. A new 99 hour activity found in Y was found to be due to an isotope of mass 175. Present evidence points to a mass of 177 for the short-lived activity resulting from neutron bombardment of Y. For more complete data see MDDC-465 and MDDC-466.

MDDC - 429 **This is an abstract only. For complete report see MDDC-905.**

MDDC - 430 A Non-Gravimetric Method for the Determination of Uranium on Platinum Discs, by R. C. Lilly. 16p.

A volumetric method is described for the determination of uranium on platinum discs which does not involve direct weighing of the deposited film. A statistical analysis of the results obtained indicates that the procedure is more consistent than that based on a gravimetric method and offers a relatively quick and convenient means for obtaining uranium assay results where an accuracy of approximately 99% is desired.

MDDC - 431 The Fluorination of Perhalogen-Olefins, by W. T. Miller. 16 p. (See also Industrial and Engineering Chemistry, Vol. 39. p. 401-404. March, 1947)

Liquid-phase reaction of CFCl:CFCl with undiluted F at 0° and at -55° gives, respectively, 13% and 8% CF_3CF_2Cl, 19% and 17.4% CF_2ClCF_2Cl, 14.8% and 10.5% $CF_2ClCFCl_2$ 3.4% and 1.1% $CFCl_2CFCl_2$, 6.5% and 30% $C_4Cl_4F_6$ (I), 7.2% and 3.8% $C_4Cl_5F_5$, and 4.4% and 2.1% $C_4Cl_6F_4$. At -78°, 44% I is formed. Under similar conditions, at 0 or -52°, $CF_3CCl:CF_2$ gives 218% or 0% C_3F_6, 24.7% or 15.2% C_3F_7Cl, 1.9% or 0% C_3F_5Cl, 2.0% or 0% $C_3F_6Cl_2$, and 30.0% or 62.5% $C_6F_{12}Cl_2$. F entering into the dimers occupies the 1,4-positions. Liquid-phase fluorinations of $CCl_2:CCl_2$, $CF_3CCl:CCl_2$, $CF_2ClCF:CFCF_2Cl$, and $CF_3CF_2CF:CF_2$ give analogous reactions, but $(CF_3)_2C:C(CF_3)_2$ shows only addition and no dimer is formed. Similar fluorination of perfluorobutadiene and its dimer and trimer give complex mixtures of polymers with high b.p. and viscosities. These are suitable for lubricating oils. Fluorination of perchlorobutadiene at 0° gives yields of 4.5-8.5% $C_4Cl_5F_5$, 20.5-32.5% $C_4Cl_6F_4$, and 15-18% $C_4Cl_7F_3$. When fluorination of perfluoro olefins is carried out in the vapor phase, little dimerization occurs and simple saturation is the main reaction. Vapor-phase fluorination with CoF_3 at 180-200° also avoids dimerization.

MDDC - 432 The Preparation and Reactions of Perfluorobutadiene-1,3, by W. T. Miller. 8p.

Perfluorobutadiene was prepared by dechlorinating 1,2,3,4-tetrachloroperfluorobutadiene with zinc dust in alcoholic suspension.

$$CF_2ClCFClCFClCF_2Cl \xrightarrow[\text{alcohol}]{Zn} CF_2{=}CFCF{=}CF_2 \quad \text{b.p. } 6.6^{\circ}$$

Perfluorobutadiene was found to be a highly unsaturated reactive material which was readily attacked by oxidizing agents such as aqueous $KMnO_4$ and by the halogens. It also underwent thermal and peroxide promoted polymerization. This behavior was in marked contrast to that of perchlorobutadiene, a comparatively inert material, and paralleled more nearly the reactivity shown by butadiene.

The thermal polymerization of perfluorobutadiene was investigated over the temperature range 100-200°. Reactions were carried out by heating perfluorobutadiene in steel bombs at 100 to 200° in a constant temperature oven. The diene was distilled into the bombs under a dry nitrogen atmosphere, and only trace amounts of water vapor or oxygen were normally present. The reaction product was readily separated into its major components, which differed by C_4 units, by distillation. The recovered perfluorobutadiene fraction contained perfluorocyclobutene, and the composition of this fraction was determined by chlorination and separation of the resulting 1,2-dichloroperfluorocyclobutane and 1,2,3,4-tetrachloroperfluorobutane by distillation.

The polymerization products were perfluorocyclobutene, dimers which boiled at 98-100°, trimers, b.p. 64-66° at 10 mm., and some higher boiling material. In some of the higher temperature runs small amounts of a low boiling C_8F_{12} were also formed.

MDDC - 433 The Preparation of Low Polymers of Trifluorochloroethylene and Their Utilization for the Production of Chlorofluorocarbon, by W. T. Miller, 23p. (See also Industrial and Engineering Chemistry 39, p. 333-337. March 1947.)

Lubricants of high chemical stability were prepared by the polymerization of C_2ClF_3 (I) in solvents which acted as chain transfer agents to control the molecular weight of the polymers while permitting good polymer conversions. Of a number of halogenated solvents tried, $CHCl_3$ was found to be the most effective. A bomb was charged with 2700 g. EtOH-free $CHCl_3$, 300 g. I, and 15 g. (benzeyl peroxide) and heated at 100° for 105 minutes. An 86% yield of polymer was obtained, of which 26% boiling range 120-220° at 0.3 mm. and 51% boiling range above 220° at 0.3 mm. The crude polymer could be further stabilized by fluorination. Thus 234 g. crude polymer, boiling range 110-220° at 0.3 mm and containing 39.1% Cl, was treated at 170-200° with three portions of CoF_3, totaling 227 g. to yield 191.3 g. of the oil fraction boiling range 100-200° at 0.3 mm. and containing 30.9% Cl. The following properties were found for the polymer oil boiling range 100-200° at 0.3 mm: Index of refraction at 20°C varied 1.39-1.40, density at 20°C varied 1.94-1.97, density at 100°C varied 1.83-1.86, average molecular weight 770, and viscosity at 100°F and 210°F in centistokes for various fractions: b.(boiling range) 100-10°, 22.9, 2.88; b. 110-20°, 59.4, 4.73; b. 120-30°, 104, 6.19; b. 130-40°, 185, 8.20; b. 140-60°, 403, 13.0. Such oil was found to be satisfactory as a vacuum-pump sealant and as a sleeve-bearing lubricant. Higher polymers of I can be pyrolyzed at 350-400° and 25 mm. pressure for reconversion to I and lower polymers.

MDDC - 434 Radiations from Radioactive Lanthanum (140), by A. C. G. Mitchell, L. M. Langer, L. J. Brown. 1p.

Radioactive lanthanum, La^{140}, which occurs as a product in uranium fission has been investigated. La^{140} grows from a Ba^{140} parent of 300 hours half life. In order to measure the energy of the gamma rays from a separated La^{140} source, the range of Compton electrons, ejected from an aluminum radiator, was measured by coincidence counters. The most energetic gamma ray was thus found to have an energy of 2.0 ± 0.10 Mev.

By placing the source between two gamma ray counters, gamma-gamma coincidences were found. It is estimated that there are two gamma ray quanta per disintegration. An absorption curve of the gamma rays showed a gamma ray of 2.0 Mev. and one of approximately 300 kv.

The beta ray end-point was found to be 1.96 Mev. Beta-gamma coincidences were found. The number of beta-gamma coincidences per recorded beta ray was independent of the energy of the beta rays indicating a simple beta ray spectrum.

Experiments performed on a separated Ba^{140} source showed that the intensity of the gamma rays grew from the barium with the expected period. In these experiments the barium source was placed in a coincidence apparatus set to measure Compton electrons from gamma rays of energy greater than 500 kv. Both the coincidence rate and the singles rate grew in a manner to be expected if the La^{140} daughter emits the gamma rays, and the Ba^{140} parent emits no high energy gamma ray.

MDDC - 435 Absorption Spectra of Uranium Compounds in Aqueous Solution, by A. R. Nichols Jr., C. Cropp. 17p.

The absorption spectra of aqueous solutions of uranous chloride, bromide, iodide, perchlorate, and sulfate have been recorded. All show main absorption bands centering at 650, 550, 495, and 430 millimicrons, although the sulfate shows minor differences from the others.

The spectrum of ammonium uranous oxalate and that of an unknown fluoride-chloride complex were found to be similar to those of the other uranous solutions, but displaced appreciably in wave length.

Spectra of UCl_3, UO_2Cl_2, and the uranyl carbonate complex are shown for comparison.

MDDC - 436 Autoxidation of Uranous Salts in Water Solution, by A. R. Nichols, Jr. 24p.

In the autoxidation of aqueous uranyl chloride, there is an increase in hydrogen ion concentration and an oxygen uptake which is in agreement with the equation:

$$2U^{++++} + 2H_2O + O_2 = 2UO_2^{++} + 4H^+$$

The rate of autoxidation in solutions containing 0.06 moles U^{++++} per liter is appreciably increased by the addition of as little as 0.00002 moles per liter of Cu^{++}. At Cu^{++} concentrations from 0.001 to 0.2 molar, the rate is proportional to the 0.82 power of the cupric ion concentration.

The autoxidation is first order with respect to oxygen, while in the presence of copper, the reaction is first order with respect to uranium. The rate is decreased by hydrogen ion, chloride ion, and sulfate ion, while cobaltous, chromic, ferric, and uranyl ions have little or no effect.

MDDC - 437 The Preparation of Uranium Metal By Thermal Dissociation of the Iodide, by C. H. Prescott, Jr. F. L. Reynolds, J. A. Holmes. 22p.

Conditions are given for the formation of uranium metal on a hot tungsten filament from the tetraiodide of uranium. The tri-iodide of uranium is heated in the presence of iodine at 800°K forming the tetraiodide, which is subsequently decomposed on the filament to uranium metal and iodine or the tri-iodide and iodine at temperatures slightly below the melting point (1330°K) of Uranium. Equilibrium conditions are assumed and a thermodynamic presentation is given involving conditions at the reaction vessel surfaces and at the hot filament surface. Experimental and estimated values of the free energy change for the reaction $UI_3(g) = U(1) + 3I(g)$ are given at three temperatures, their difference amounting to only 6.5 kilocalories. A bibliography of the literature and patent issues pertaining to the method is included.

MDDC - 438 General Chemistry and Metallurgy (Chapters 1 thru 10, Collected Papers. Volume 19-B. Division IV, Plutonium Project Record, National Nuclear Energy Series), by L. L. Quill, et al Editorial Board.

This document is made up of a series of papers as follows:

MDDC - 438-A

Investigation in the Liquid-Solid Equilibria of Two Component Systems Composed of the Bromides and Iodides of Strentium and Barium, by D. D. Cubicotti, C. D. Thurmond. 11p.

Tentative temperature-composition diagrams of the liquid-solid phase equilibria between the six salt pairs obtained from the bromides and iodides of strontium and barium are presented in the light molecular weight salt baths. A plot of water vapor pressure over strontium and barium bromide and iodide hydrates versus temperature is included.

MDDC - 438-B

Temperature-Composition Diagrams of Metal-Metal Halide Systems, by E. D. Eastman, D. D. Cubicootti, C. D. Thurmond. 11p.

The phase diagrams of the systems Ba-$BaCl_2$, Ba-$BaBr_2$, Sr-$SrBr_2$, Sr-SrI_2, Ce-$CeCl_3$, Ca-$CaCl_2$ were studied by thermal analysis. All the systems are of the same type. The two components which are mutually soluble to a limited extent with a region of immiscibility between the limits of the miscibility gap for the Ca-$CaCl_2$ system are also reported. The systems give evidence that no "fog" formation takes place, but that all the metal dissolves in the solution.

MDDC - 438-C The Thermodynamic and Physical Properties of the Elements, by L. Brewer. 51p.

This paper tabulates the physical and thermodynamic properties of the elements. It contains tables of heat contents, vapor pressures, heats of vaporization, and entropies of vaporization for sixty to seventy of the elements.

MDDC - 438-D Thermodynamic and Physical Properties of Nitrides, Carbides, Sulfides, Phosphides, and Silicides, by L. Brewer, L. Bromley, P. W. Gilles, and N. L. Lofgren. 29 p.

The free energies, heats and entropies of formation at 298°K and the melting points and solubilities are given for many nitrides, carbides, and sulfides. Melting temperatures are given for some silicides and phosphides. To enable interpretation of high temperature reactions in vacuum systems, a tabulation of gaseous compounds stable at 1500°K, 2000°K, and 2500°K in the pressure range 10^{-3} to 10^{-5} mm Hg is presented. With the aid of this, a tabulation of possible refractory nitrides, carbides, and sulfides is presented for the same temperature and pressure range giving the volatilities of the various refractory substances. A brief discussion of the application of these compounds as refractories in high temperature-high vacuum systems is given.

MDDC - 438-E The Thermodynamic Properties of Common Gases, by L. Brewer. 22p.

Free energy, entropy, and other thermodynamic values are tabulated for the common gases of importance in high temperature reactions. In addition to the tables, numerous references are given to tables of thermodynamic functions of many of the less common gases.

MDDC - 438-F The Thermodynamic Properties of the Halides, by L. Brewer, L. A. Bromley, P. W. Gilles, N. L. Lofgren. 226p.

The thermodynamic properties of the liquid and solid halides of practically all elements are tabulated in this paper. There are five tables altogether.
Table I gives the heat contents, $H_T - H_{298}$, and entropy increments, $S_T - S_{298}$, above 298°K. for the solid and liquid halides.
Table II gives values of $-(F-H_{298})/T$ at 298.1°K., 500°K, 1000°K., and 1500°K. for the solid and liquid halides.
Table III gives values of $(\Delta F - \Delta H_{298})/T$ at 298.1°K., 500°K., 1000°K., and 1500°K. and values of ΔH_{298}, the heat of formation at 298.1°K., for the solid and liquid halides as well as a discussion of the high temperature chemistry of the halides.

For those halides which are gaseous even at 298°K. and therefore are not included in the above tables, Table IV gives the S_{298}, ΔH_{298}, ΔS_{298}, ΔF_{298}, and ΔF_{500} values for such gases.
Table V gives the ionic radii of ions of the elements, their heats of formation from the neutron gaseous elements, the heat evolved upon hydration of the gaseous ions, the heat of formation of aqueous ions, and the entropies of aqueous ions. Many of the heats of formation of the halides were dependent upon the aqueous ion values.

There are four appendices. The first appendix shows the relations between the various thermodynamic properties of elements, compounds, and solutions. With the aid of the diagram in Appendix 1, Appendix 2 illustrates the use of lattice energies in estimating and checking heats of formation of compounds. Appendix 3 illustrates the use of heats of solutions in estimating and checking heats of formation of compounds. Appendix 4 illustrates the use of the tables for various thermodynamic calculations.

MDDC - 438-G **Fusion and Vaporization Data of the Halides, by L. Brewer. 149p.**

Tables of melting points, heats of fusion, heats of vaporization, boiling points, and vapor pressures of the halides are given. A discussion of the factors affecting volatility is given.

MDDC - 438-H **The Thermodynamic Properties of Molybdenum and Tungsten Halides and the Use of The Metals as Refractories, by L. Brewer, L. A. Bromley, P. W. Gilles, N. L. Lofgren. 49p.**

A summary of the high temperature chemistry of the metals molybdenum and tungsten and their halides is presented with emphasis upon the suitability the metals as refractories. Conditions for non-attack of the metals by halogens, hydrogen halides, and other halogen producing compounds are indicated. The methods of preparation of the halides and their high temperature properties are presented.

MDDC - 438-I

Heats of Formation of CeS, Ce_3S_4, and Ce_2S_3 at 25°C, by M. W. Evans. 16p.

The heats of solution of CeS, Ce_3S_4, and Ce_2S_3 in 1 M HCl at 25°C. have been measured. Heats of formation are calculated, using rhombic sulfur as the standard state, and are found to be

CeS	Δ H(form.)298	= 117.9 Kcal.
Ce_3S_4	"	= 421.5 Kcal.
Ce_2S_3	"	= 300.5 Kcal.

The results are interpreted and correlated with other experimental data.

MDDC - 438-J

Heat of Reaction of the Cerous-Ceric Couple in 0.5 Molal Perchloric Acid at 25°C, by B. J. Fontana. 16p.

The heat of reaction of the cerous-ceric couple in 0.5 molal perchloric acid, at 25°C, has been determined calorimetrically. Perchloric aicid, oxalic acid, and hydrogen peroxide were used as thermo-chemical standards. The results using oxalic acid were unsatisfactory because of uncertainties in the state of the product carbon dioxide. Satisfactory results were obtained using hydrogen peroxide indirectly; that is, by determination of the heat of reaction with ferrous ion and then using the ferrous-ferric couple so determined to obtain the cerous-ceric heat of reaction. The final values obtained for ΔH_{298} (kcal per mole) were for ferrous-ferric, + 9.53 $\pm$ 0.04; and for cerous-ceric, + 37.88 $\pm$ 0.05.

MDDC - 439 Comparative Lethal Effects of External Beta Irradiation, by J. R. Raper, R. E. Zirkle, K. K. Barnes. 18p.

The acute lethal effects of total surface beta irradiation have been investigated in a series of laboratory animals ranging in size from 7 to 2000 grams. The median lethal dose, the LD50, of external beta rays varied from 2200 roentgen equivalents physical in the smallest animal of the series to 17,500 rep in the largest.

Gamma ray survival studies with the same strains of animals demonstrated LD50's ranging from 310r to1270r,the sensitivity showing no correlation with size. A comparison of the total energy absorbed, in rep grams, as beta rays and as gamma rays, to produce 50% killing gave total beta/total gamma ratios for the several animals of the series as follows: baby rats (one day old), 2.01: mice, 1.75; rats, 0.84; guinea pigs, 3.24; and rabbits, 0.92.

The relation between absorbed energy required to kill 50% of the individuals of each species and animals size may be expressed in the following equation:

$$t^E = KW,$$

where t^E is the total energy absorbed in rep grams, W, the weight of the animal, and K, a constant.

The small variation in the observed values of K for the different animals indicates negligible sensitivity difference to beta rays among the species employed. This finding is contrasted with well established sensitivity differences of the same animals to the penetrating radiations, x rays and gamma rays.

MDDC - 440 Survey of the Fission Product Isotopes, by J. M. Siegel. 47p. (See also Review of Modern Physics, Vol. 18, p. 513-544, October 1946 and Journal of the American Chemical Society, Vol. 68, p. 2411-2442, November 1946).

This paper contains a table listing the known fission product isotopes as of June 1946. The radioactive properties of the isotopes are given in the table. See MDDC-456 for a revision to this report.

MDDC - 441 The Dipole Moment and Molecular Structure of Uranium Hexafluorides, by C. P. Smyth, N. B. Hannay. 5p.

The dielectric constant of the vapor of uranium hexafluoride was measured over a range of temperature and pressure. (From an average polarization of 27.1 and density of the liquid at 65^{O}, 3.667, a dielectric constant value 2.18 was calculated). Although the possibility of a small moment, less than 0.5×10^{-18}, is not definitely excluded by the experimental data, it is logical to conclude that the moment of the molecule is zero.

The zero moment of the molecule shows that it is symmetrical in form, a conclusion shown to be consistent with the results of electron diffraction and X-ray analysis.

MDDC - 442 Application of Ion-Exchange to Inorganic and Radiochemical Research, by J. A. Swartout. 9p.

This paper is an outline of a lecture presented orally at Northwestern University.

MDDC - 443 **Fluorescence Analysis For Uranium, by E. Zebroski, T. W. Newton. 16p.**

An adaptation of a colorimeter for the rapid estimation of small amounts of uranium to ± 5% by fluorescence of a sodium fluoride bead or fluoride-carbonate melt is described. Solutions containing from 0.1 to 1000 micrograms per milliliter may be tested directly. The limit of visual detection on a 20 mg. bead is about 0.0003 micrograms of uranium.

A periodic chart of interferences is presented. The strongest interferences center around the latter part of each transition series of elements. Several convenient purification methods are suggested and a simple test for interferences is given.

MDDC - 444 **The Radiobiological Importance of Specific Ionization, by R. E. Zirkle. 29p.**

It is shown that, in the production of injurious effects in both the higher plants and the higher animals, the amount of injury produced per unit of absorbed energy increases with the specific ionization of the radiation. In particular, the injurious action of fast neutrons is greater than that of X-rays or gamma rays by factors ranging up to 20, and the effectiveness ratios are calculated in such a way as to make them conservatively low. Although most of the effects on mammalian tissues show effectiveness ratios ranging from 2 to 3.5, it must be pointed out that to date comparatively few neutron investigations have been carried out on mammalian tissues in vivo. It is shown that different effects on the same biological object may exhibit considerably different effectiveness ratios, therefore a distinct possibility exists that further observation will disclose important injurious effects on mammals which have neutron/x-ray effectivenss ratios ranging up to 10. From the protection standpoint, only one such biological effect, though at present unknown, is a threat. Until extensive and numerous investigations allay this threat by failure to reveal injurious effects extremely sensitive to specific ionization, special precautions seem to be indicated when setting tolerance doses in situations where fast neutrons constitute a sizeable fraction of the total radiation present. These considerations are especially pertient in case X-ray thimble chambers are used in measuring the total radiation. If uncorrected Victoreen measurements are used in comparing the effectiveness of fast neutrons and X-rays, the apparent effectiveness ratios for the known injurious effects on mammalian tissues range up to more than 8. Carbon-walled chambers are even more misleading.

MDDC - 445

A Proposed Experiment on the Ponderomotive Forces Exerted by Microwaves on Dielectric Media, by O. Halpern. 1p.

Some formulations of relativistic electrodynamics lead to the result that an electro-magnetic wave propagating itself in a dielectric medium exerts a force density given by the self-explanatory formula

$$\vec{b}\,\frac{\epsilon\mu - 1}{c^2}\,\frac{\delta\vec{l}}{\delta t}$$

The smallness of (b) has so far been considered to prevent experimental verification. The author proposes an experiment in which the force of a standing microwave in a $\lambda/4$ layer be measured preferably with a static magnetic field superimposed in the direction of the r.f magnetic field. A (resonant) quartz-plate may be used as a piezo-electric indicator. This experiment if successful would permit for the first time to measure the actual time dependence of Poynting's vector.

MDDC - 446

Divergent Chain Reaction in Systems Composed of Uranium and Carbon, by L. Szilard. 40p.

It is shown that a divergent chain reaction may be maintained in a system composed of uranium and carbon. Conditions particularly favorable for a chain reaction are obtained if instead of using a homogeneous mixture of uranium and carbon, a large number of rather small spheres of uranium metal are used, embedded in a mass of graphite. The small uranium spheres may form a close-packed hexagonal or cubic lattice embedded in a large sphere of graphite. The average number of fast neutrons emitted by uranium for one thermal neutron absorbed by uranium is calculated from known experimental data and is found to be about 2. In this system conditions for a chain reaction become more and more favorable as the temperature increases and it is shown that a chain reaction can be expected to be self-generating in such a system at about 900°C. even if the cross-section of carbon were as high as 0.01, its present experimental upper limit. As the intensity of the chain reaction increases with increasing temperature the system is thermally unstable. It can be controlled artificially. The time within which the control would have to respond is found to be longer than one second. As much as 100 tons of graphite and 30 tons of uranium might perhaps be required in order to reach the point of divergence at which nuclear transmutation will go on with an intensity limited only by the necessity of avoiding over heating. But in so far as the capture cross-section of carbon is likely to be below 0.01, the amount of material required will probably be smaller.

MDDC - 447 Ionization Chamber and Electronic Equipment for the Observation of the Shape of one Microsecond X-Ray Pulses. by J. S. Allen, D. Hudson. 11p.

A parallel-plate ionization chamber and electronic recording equipment have been developed and used for the observation of the shape of single X-ray pulses of approximately one-microsecond duration. The use of a mixture of 0.1 CO_2 and 0.9 A in the chamber permits very rapid collection of the electrons produced by ionization of the gas. Tests have shown that an X-ray pulse of several microseconds duration, and rising and falling in less than 0.1 microseconds will appear on the CRO as a pulse with a rise and fall time of about 0.2 microseconds.

Constructional details of the chamber and electronic equipment are given. In addition, representative traces of the pulse observed from an X-ray tube operated from a Westinghouse impulse generator are included.

MDDC - 448 Time of Collection of Electrons in Ionization Chambers. by J. Allen, B. Rossi. 21p.

The drift velocity of electrons in A, CO_2, A+CO_2 mixtures, BF_3 and BCl_3 was measured as a function of the field-pressure ratio, E/p. The drift velocity in an A+CO_2 mixture was found to be greater than in either component. This information was obtained from the observation of the rise time of the pulses produced by the collection of electrons in a parallel plate ionization chamber. A source of Po alpha particles produced the necessary ionization.

MDDC - 449 **The Magnetic Moments of the Neutron and the Deuteron, by W. R. Arnold. A. Roberts. 26p. (See also Physical Review. Vol. 70. p. 766. November 1946).**

The magnetic moments of the neutron and the deuteron have been measured in terms of the proton moment. The radio-frequency resonance technique of Alvarez and Bloch was used to determine the Larmor frequency of neutron precession in a magnetic field in which the frequency of proton precession had been determined by the method of Purcell, Torrey, and Pound. The ratio of the magnetic moment of the neutron to the magnetic moment of the proton is 0.68479 ± 0.0004. The ratio of the deuteron moment to the proton moment is 0.30702 ± 0.0001, in agreement with the Columbia value. Taking the magnetic moment of the proton as 2.7896 nuclear magnetons, the neutron moment is -1.9103 ± 0.0012 and the deuteron moment 0.85647 ± 0.0003 nuclear magnetons. These values lead to a prediction of an admixture of 4.0 per cent $^3D_1$ state in the ground state of the deuteron, in agreement with the value 3.9 per cent found by Rarita and Schwinger from the magnitude of the electric quadrupol · momen of the deuteron.

MDDC - 450 **An Improved Method for Cutting Undecalcified Bone Sections and its Application to Radio-Autography, by D. J. Axelrod 9p. (See also Anatomical Record, Vol. 98, p. 19-24. May 1947).**

A method is discribed which is a modification of that developed by McLean and Bloom Anatomical Record Vol. 78. p. 333-353,(1940)

MDDC - 451 **Measurement of Transport and Inelastic Scattering Cross Sections For Fast Neutrons Part I. Method, by H. H. Barschall, J. H. Manley, V. F. Weiskopf. 16p. (See also Physical Review Vol. 72, p. 875-880, November 15, 1947).**

An experimental method for measuring transport and inelastic scattering cross sections for fast neutrons is described. The cross sections are obtained from poor geometry and back scattering measurements using a detector, the energy response of which rises above an adjustable neutron energy from zero to an almost constant value. A method of evaluation of the data is discussed.

MDDC - 452 **Measurement of Transport and Inelastic Scattering Cross Section for Fast Neutrons Part II. Experimental Results, by H. H. Barschall, et al. 25p. (See also Physical Review Vol. 72, p. 881-888, November 15, 1947).**

Measurements of poor geometry scattering and backscattering are described for neutrons of energies of 0.2, 0.6, 1.5, and 3 Mev. The following materials were investigated; C, Be, B^{10}, B^{11}, BeO, Al, Fe, Cu, Co, Ni, Ta, W, Au and Pb. Values of the cross section for inelastic scattering and the transport cross section are given for these materials.

MDDC - 453 On the Neutron-Proton Scattering Cross-Section, by D. Bohm and C. Richman. 14p. (See also Physical Review, Vol. 71, p. 567-572, May 1, 1947)

The sensitivity of the theoretical neutron-proton scattering cross section to possible variations in the quantities defining the potential has been investigated in the energy range from 0 to 6 Mev. It is found that in this energy range the variations in exchange or tensor character and range of the potential which are consistent with what is known about the interaction do not result in so large a modification of the predicted cross section as do variations in shape.

A well resembling a Yukawa potential $\frac{A \exp(-\alpha r)}{r}$ is found to yield a cross section at 6 Mev which is 10 per cent lower than that given by a square well fitted to the epithermal neutron cross section and the binding energy of the deuteron. The Yukawa well is in better agreement with the experiment than is the square well. One of the constants entering into the determination of the potential is the epithermal neutron scattering cross section in hydrogen. This was determined by extrapolating the data of Frisch with the aid of the theory, and obtained a value of 20.8×10^{-24} cm^2.

MDDC - 454 Alpha Counters as Used in Radioassay of Plutonium, by S. R. Chadwick. 42p.

A description of the amplifiers, scalers, and power supplies used with the air and nitrogen chambers is given. Circuits diagrams and shop drawings of the chambers are included in the appendix.

MDDC - 455 The Deposition of Radioactive Metals in Bone as a Potential Health Hazard, by D. H. Copp, D. J. Axelrod, and J. G. Hamilton. 13p. (See also American Journal of Roentgenology Vol. 58, p. 10-16 July 1947).

The metabolism of bone was investigated to determine the factors concerned in the absorption and deposition of Sr, Ce, Y, and Pu in the skeleton and the precise sites of localization. The chronic elimination of these radioactive materials was studied in rats, and the effects of the standard procedures used in treating chronic radium poisoning were compared. Finally, a possible mechanism for reducing the toxicity of the plutonium deposits in the bone was investigated.

Only two factors were found to have marked effect on the absorption of Sr* from the gut. These were (1) The age of the animals, and (2) The adequacy of calcium in the diet.

The results indicate an increased hazard from radioactive strontium, and presumably radium, to young, growing individuals and to those on a low calcium diet. Accordingly, work involving exposure to radio-strontium or radium should be restricted to adults, and care should be taken to maintain a high level of calcium intake in these individuals.

In contrast to strontium, no significant difference in the behavior of plutonium, yttrium, or cerium was observed.

A radio-autograph for Sr* shows that this element was deposited only in the thin shell of bone salt remaining in the shaft. Plutonium, on the other hand, was actively laid down in the uncalcified organic bone matrix below the epiphyseal cartilage and in the endosteum and periosteum. None was deposited in the cartilage itself. Yttrium was deposited superficially in the shaft with heavy deposits in the uncalcified osteoid matrix below the epiphyseal cartilage. Similarly, cerium was deposited superficially in the shaft, with scattered points of radioactivity within the shaft, and heavy deposits in the uncalcified osteoid matrix below the epiphyseal cartilage.

Sr* appeared to follow the path of calcium metabolism and was deposited only in the bone salt; Pu*, Y*, and Ce* were laid down in the uncalcified organic matrix of bone and appeared to be unrelated to calcium in behavior.

Sr* appeared to be eliminated more readily than the other elements, with a biological half-life of only 3 to 4 months. Pu*, Y*, and Ce* were excreted very slowly and the biological half-lives of these elements ranged from 1 to 3 years.

MDDC - 456 Official Revision of the Survey of Fission Product Nuclei, by C. D. Coryell. 3p.

This document lists revisions in radioactive characteristics of fission product nuclei. These revisions amend the report entitled Survey of Fission Product Isotopes, by J. M. Siegel, MDDC-440.

MDDC - 457 The Resistance Temperature Relation and the Thermoelectric Properties of Uranium, by A. I. Dahl and M. S. Van Dusen, 15p. (See also Journal of Research of the National Bureau of Standards Vol. 39, p. 53-58, July 1947).

The resistance-temperature relation for 99.9% uranium has been determined over the range 0^{o} to 900^{o}C.

The temperature coefficient of electrical resistance, $\frac{R_{100} - R_{o}}{100\ R_{o}}$ for 99.9% uranium has been found to be 0.00276 for metal annealed at 600^{o}C and 0.00261 for metal annealed at 910^{o}C.

The irregularities occuring in the resistance-temperature curve for uranium have been used as a basis for locating the transformation points in uranium. The following transformations are indicated:

On Heating	
Alpha - beta	667^{o}C
Beta - gamma	772^{o}C
On Cooling	
Gamma - beta	764^{o}C
Beta - alpha	645^{o}C

The observations on the samples of uranium are plotted. Uranium is thermoelectrically positive to platinum on the basis of the generally accepted convention, namely: if, in a simple thermoelectric circuit the current flows from

(Cont'd on next page)

MDDC - 457 The Resistance Temperature Relation and the Thermoelectric Properties of Uranium, by A. I. Dahl and M. S. Van Dusen, 15p. (See also Journal of Research of the National Bureau of Standards Vol. 39, p. 53-58, July 1947). (cont'd from page 271).

metal A to metal B at the colder junction, A is thermoelectrically positive to B. The curves indicate that the thermal emf of uranium versus platinum increases with temperature with no discontinuities or abrupt changes. The thermoelectric power, de/dt, increases from about 12 uv/^{o}C at 0^{o}C to about 42 uv/^{o}C at 900^{o}C. The alpha-beta and the beta-gamma transformation in uranium appear not to affect the thermoelectric properties. This is in marked contrast to the discontinuities in electrical resistance at about 660^{o} and 770^{o}C.

MDDC - 458 Operation of Proportional Counters at Pressures Above Atmospheric, by B. C. Diven. 28p.

As a continuation of the work described in a previous Los Alamos report the operation of proportional counters above Los Alamos atmospheric pressure (0.77 atmospheres) has been investigated. The properties studied include gas multiplication as a function of voltage and pressure, effect of electron attachment, spread in pulse height, and extent of the region of proportionaltity.

MDDC - 459 Calculating High Vacuum Systems, by W. P. Dryer. 39p. (See also Chemical Engineering Vol. 54, p. 127-131, November 1947).

Methods and formulas are given for the calculation of the size of equipment used in creating high vacuum in vessels of industrial size. The formulas are presented in terms and units that engineers will readily understand and be able to apply; they are, in fact, the practical formulas for the resistance to flow of gases at low pressure.

The following subjects are treated: Viscous Flow Resistance, Formulas, Conductance-- General, Pressure Range of Formulas, Free Molecular Flow Conductance, Viscous Flow Conductance, Combined Viscous and Free Molecular Flow Conductance, Evacuation by Mechanical Pumps, Sizes of Pipe for Rough Evacuation, Derivation of Formulas of Viscous Flow Resistance.

MDDC - 460 Pile Theory Notes for M. I. T. Seminar, by T. T. Feld, F. L. Friedman. 44p.

This paper constitutes notes which are the basis for a seminar held at M. I. T. The subjects discussed are: Review of Relevant Concepts from Nuclear Physics; The Homogeneous Closed Box with Monokinetic Neutrons; Time Dependence of the Neutron Density; Time Dependence of the Neutron Density When Delayed Neutrons are Considered; Measurement of η (f - 1); The Slowing Down of Neutrons without Resonance Capture; The Slowing Down of Neutrons Resonance Capture Considered; Measurement of (p), the Resonance Escape Probability; Measurement of (f), the Thermal Utilization; Controlling the Chain Reacting Box; Homogeneous Thermal Neutron Pile; The Slowing Down of Neutrons in a Pile; The Time Behavior of Non-critical Piles; Generalization to Include Other Harmonics; The Approach to Critical.

MDDC - 461 **Some Factors Affecting The Cupferron Extraction Procedure For Estimation of Trace Amounts of Plutonium, by R. Fryxell, R. Kleinschmidt. 12p.**

The effects of a number of factors on the cupferron extraction of plutonium have been observed during attempts to apply it to the analysis of biological materials. These effects are presented in some detail. The ferric cupferride complex is shown to be stronger than the plutonium cupferride complex. A method is proposed for the assaying of hexavalent plutonium for small amounts of reduced plutonium. The method is based on the cupferron extraction.

MDDC - 462 **Thermal Conductivity Gas Analyzer, by General Electric Company. 19p.**

This document is an instruction and operating manual for the General Electric Thermal Conductivity Gas Analyzer.

MDDC - 463

Theory of the Refraction and the Diffraction of Neutrons by Crystals, by M. L. Goldberger, F. Seitz, and E. P. Wigner. 40p. (See also Physical Review, Vol. 71, p. 294-310, March 1, 1947)

The refraction and diffraction of neutrons by crystalline matter is discussed theoretically on the basis of a generalization of a method first used by Fermi. In the present treatment it is assumed that the nuclei of which the matter is composed both scatter and absorb neutrons; however, the approximations used are valid only when the "phase shift" of the wave functions by the nuclei is small. This condition is satisfied for a large number of nuclei in cases in which thermal neutrons are being considered. In the region of long wave-length, the medium behaves like an optical medium characterized by a refractive index $\underline{n}$ and an extinction coefficient $\underline{k}$ which are related to the cross sections $\sigma_{\underline{s}p}$ and $\sigma_{\underline{a}p}$ for scattering and absorption, respectively, by means of the equations:

$$\underline{n} = 1 + \underline{n}_0 \pm \Sigma_{\underline{p}} \pm \frac{2\pi}{\underline{k}^2} \frac{\sigma p_{\underline{s}}}{4\pi}, \qquad n = \underline{n}_0 \Sigma_{\underline{p}} \frac{\sigma p_{\underline{a}}}{2\underline{k}}$$

Here $\underline{n}_0$ is the number of atoms or molecules per unit volume, $\underline{k}$ is the wave number of the neutron, and $\underline{p}$ is summed over all atoms of the constituent molecules. The sign appearing before each term in the first summation is related to the sign of the "phase shift" for the corresponding nucleus. It is shown that these equations are valid whenever Bragg's condition is not satisfied. The problem of neutron diffraction is treated by a method closely related to that used in the dynamical theory of X-ray diffraction and the results obtained bear a very close relation to those for X-rays.

MDDC - 464

Slow Neutron Velocity Spectrometer Studies II: Au, In, Ta, W. Pt, Zr., by W. W. Havens, Jr., C. S. Wu, L. J. Rainwater, C. L. Meaker. 24p. (See also Physical Review Vol. 71, p. 165-173, Feburary 1, 1947).

The slow neutron velocity spectrum of Au, In, Ta, W. Pt, and Zr have been investigated. The results for Au and In check the values previously obtained using the "old" system. The results for the gold level at (4.8 ± 0.1) ev. with $\sigma_0\Gamma^2 = 600$, and for the main Indium level at (1.44 ± 0.02) ev. with $\sigma_0\Gamma^2 = 210$ agree with the earlier results. Additional Indium levels were found at (3.8 ± 0.2) ev. with $\sigma_0\Gamma \sim 120$ and at (8.6 ± 0.4) ev. with $\sigma_0\Gamma \sim 300$.

The cross section curve for Ta below 1 ev. is well matched by $\sigma = [(7.2 \pm 0.4) + (3.0 \pm 0.1) E^{-1/2}]$. Tantalum has levels at (4.1 ± 0.1) ev. with $\sigma_0\Gamma^2 \sim 44$, at (10.0 ± 0.3) ev. with $\sigma_0\Gamma^2 \sim 25$, at (13 ± 0.5) ev. with $\sigma_0\Gamma^2 \sim 3$, at (22 ± 2) ev. with $\sigma_0\Gamma^2 \sim 18$, at (37 ± 3) ev, with $\sigma_0\Gamma^2 \sim 400$ and other dips probably indicating multiple strong levels near 100 ev, 300 ev, and at higher energies.

The cross section curve for W below 1 ev. is well matched by $\sigma = [(5.7 \pm 0.2) + (2.72 \pm 0.05) E^{-1/2}]$. There are levels at (4.0 ± 0.1 ev with $\sigma_0\Gamma^2 \sim 13$, at (7.4 ± 0.2) ev. with $\sigma_0\Gamma^2 \sim 5$, at (18.0 ± 0.5) ev. with $\sigma_0\Gamma^2 \sim 3000$ (perhaps multiple), at (45 ± 2) ev with $\sigma_0\Gamma^2 \sim 400$ (perhaps multiple) at (180 ± 20) ev. with $\sigma_0\Gamma^2 > 10{,}000$ if single (probably multiple), and dip at 1100 ev which is probably multiple.

The results for Pt show pronounced crystal interference effects in the thermal region. The 1/v line is probably $\sigma = [(12.0 \pm 0.3) + (1.03 \pm 0.06) E^{-1/2}]$. There are levels at (11.5 ± 0.4) ev with $\sigma_0\Gamma^2 \sim 55$, at (18.2 ± 1) ev with $\sigma_0^2\Gamma \sim 30$, and broad dips near 100 ev and near 1000 ev indicating the presence of several strong unresolved levels.

The results for Zr below 0.6 ev are well matched by $\sigma = [(6.8 \pm 0.3) \pm (0.74 \pm 0.10) E^{-1/2}]$. There are weak levels at (1.09 ± 0.03) ev with $\sigma_0\Gamma \sim 5$, and at (2.30 ± 0.07) ev with $\sigma_0\Gamma \sim 8$. A complex dip near 7 at (7.6 ± 0.4) ev with $\sigma_0\Gamma^2 \sim 4$.

MDDC - 465 Artificial Activities Produced in Europium and Holmium by Slow Neutron Bombardment, by M. G. Inghram and R. J. Hayden. 2p. (See also Physical Review, Vol. 71, p. 130, January 15, 1947).

A HNO_3 solution of Ho_2O_3 was irradiated with slow neutrons; the sample was dispersed by a mass spectrograph, and the activity of the isotopes was determined by the double photographic emulsion technique. An isotope of 27.5-hour half-life has a mass of 166, this accounts for 96% of the activity. The other 4% has a half-life of 3 hours and is due to Dy present as an impurity. Eu_2O_3 was similarly irradiated and processed. The 9.2-hour activity is due to Eu^{152}. Lines at 152 and 154 were found after two weeks and after four months at the same relative strengths. This line at 152 was not due to 9.2-hour Eu; neither line can be due to Nd, Il, Sm, or Gd. Thus Eu must have two long-lived activities. There is no positron emission. There are at least two β-rays, and a γ-ray of 1.4 Mev.

MDDC - 466 Neutron Induced Activities in Lutecium, Ytterbium, and Dysprosium, by M. G. Inghram, R. J. Hayden, D. C. Hess, Jr. 1p. (See also Physical Review Vol. 71, p. 270, February 15, 1947).

Nitric acid solutions of Lu_2O_3, Yb_2O_3, and Dy_2O_3 were irradiated with neutrons in the Argonne heavy water pile. Decay curves of the irradiated lutecium sample showed 3.4 hour and 6 6 day activities as reported by Flammersfeld and Mattauch Decay curves of the ytterbium sample showed a 2.7 hour activity (probably the same activity reported by Marsh and Sugden as 3.5 hours) and also a 102 hour activity not previously reported. No evidence of the 41 hour activity reported by Pool and Quill was found. Decay curves of the dysprosium sample showed the 2.5 hour activity reported by Marsh and Sugden.

Assignment of mass to three of these active isotopes was made as follows. A portion of the sample containing the activity in question was placed on the filament source of a mass spectrograph. Operation of the spectrograph separated the isotopes and deposited them on a photographic plate. The position of the active isotope on this plate was determined by placing a second photographic plate face to face with the original. The disintegration of the active isotope on the first plate produced developable images on both plates. Comparison of the position of this active deposit with the normal mass spectrum on the original plate determined the mass of the active isotope. This method of mass assignment gives results without the necessity of assuming the nuclear reaction by which the isotope is formed and is therefore frequently valuable in establishing the nuclear reaction. Using those techniques the following masses were assigned: 6.6 day lutecium, 177; 192 hour ytterbium, 175; and 2 5 hour dysprosium, 165.

MDDC - 467 A method of making thin uranium oxide films on platinum foils, by T. Jorgensen. 4p.

A thin film of U_3O_8 is made on platinum by putting a mixture of alcohol solution of uranyl nitrate and lacquer on a plate which is slowly rotated during drying, after which the film is heated.

MDDC - 468 Properties of Be^{10}, by J. Levinger, E. Meiners. 17p. (For a related document see also Physical Review Vol. 71, p. 586-588, May 1, 1947).

Beryllium activity has been measured from two deuteron activations, an upper limit set on activity due to neutron capture. Using an estimated d-p yield, the authors estimate the half-life at 10^7 years; the neutron activation sets the lower limit as 10^6 years. Absorption curves on the beta activity give an energy of $0.71 \pm .02$ Mev; in fair agreement with B^{10} - Be^{10} mass difference of 0.55 Mev. There appears to be no branching in the beta decay; the gamma activity of the samples measured is attributed entirely to contamination by Be^7.

MDDC - 469 The Electrolytic Preparation of Thin Films of Plutonium Oxide, by M. L. Miller. 2p.

Thin films of plutonium oxide, up to 0.1 mg of metal per cm^2 have been prepared electrolytically on platinum. The method depends on the use of the plutonyl ion in alkaline solution. It is presumed that on reduction at the cathode, a thin layer of insoluble hydroxide is deposited. This is subsequently ignited to the oxide.

Method: The arrangement for electrolysis and the electrolyte solution are those described by M. Kahn (UCRL-612). The solution consists of a KOH-K_2CO_3 mixture containing 1.78 g of KOH (Baker's analyzed) plus 4.0 g of K_2CO_3 per 200 cc of solution. To 15 cc of this is added 5 cc of water containing the plutonyl ion, as nitrate. Electrolysis is carried out with a rotating platinum anode at 3v and a current density of approximately 10 ma/cm^2. The course of the electrolysis is followed by removing small amounts (appr. 7 microliters) at hourly intervals for counting. When the count has dropped to less than one tenth of its initial value, or if it begins to rise, electrolysis is stopped and the plate washed and ignited. The electrolysis usually requires 2-3 hours. The amount of material on the plate must be determined by counting, since as much as 15-25% of extraneous material may be deposited. About 85% of the metal is recovered on the plate; the remainder probably being in the form of an insoluble precipitate on the sides of the chimney.

Whether the carbonate serves any useful purpose or whether its omission or a change in its concentration would increase the efficiency of the electrolysis is one of the many factors yet to be investigated.

The foils so prepared show interference rings and are very similar in appearance to electrolytically prepared U_3O_8 foils.

MDDC - 470 Calculation of Current Carried by the Electrons in a Cylindrical Ionization Chamber, by D. Nicodemus. 4p.

The current in an ionization chamber in which it is assumed that there is no electron attachment is carried partly by the electrons and partly by the positive ions. The motion of both the ions and the electrons induces charges on the collecting electrode, and if both electrodes of the chamber are connected by a conductor a current will flow. This total ionization current may be thought of as the sum of two currents, I^+ and I^-, the former due to the motion of the positive ions and the latter due to the motion of the electrons. In a steady state with the gas throughout the chamber being uniformly ionized, these two currents, I^+, and I^-, may or may not be equal depending upon the geometry of the chamber. For a parallel plate chamber they are equal. In the case of a cylindrical chamber, with a central electrode which collects the electrons, the current resulting from the motion of the positive ions is less than the current due to the electrons.

The difference between I^+ and I^- can be simply explained by an energy consideration. Their ratio depends upon the relative amount of work done in removing the electrons and in removing the positive ions from the collecting volume of the chamber. Since the electrons all move in the direction of higher fields, and the position ions all move in the direction of weaker fields, more work is done in collecting the electrons than in the collection of the positive ions. For the case of the chamber of this report where the radius of the inner electrode = .0125'' and the radius of the outer electrode = .970'', I^- is about 88% of the total current.

MDDC - 471 Review of Air Monitoring Procedures at Clinton Laboratories, by H. M. Parker. 12p.

Gas monitoring procedures used at Clinton Laboratories are reviewed. Tolerable concentrations of various radioactive isotopes are discussed as are continuous measurement of the beta and gamma activity in the air, internal measurements of activity in the air, nature of the incident radiations, film meters, spot checks of areas suspected of temporarily increased activity, and laboratory methods of gas monitoring.

MDDC - 472 Po Alphas on BF_3 as a Neutron Source, by H. T. Richards. 6p.

A Po-BF_3 source consisting of ~40 millicures of Po was deposited on the inside of a $\frac{1}{2}$'' x $\frac{1}{2}$'' platinum cylinder which fitted into a slightly larger iron cylinder containing ~200 lbs/in^2 gauge pressure of BF_3. By the use of a flat-response neutron counter, this source was compared with a standard Ra-Be source and found to have a strength of $\sim 0.6 \times 10^4$ neutrons/sec. From yield data on (α,n) reactions, a neutron yield of $\sim 10^4$ neutrons/sec is computed.

MDDC - 473 **High Frequency Insulator and Vacuum Gap Breakdown Tests, by F. Schmidt. 15p.**

The Zircon porcelain insulators which are to be used to support the 184" cyclotron dee, and to support the stator ring of the 184" cyclotron rotary capacitor have been tested at 13 m. c. r. f. voltage. In accordance with the results of these tests, a minor design change has been suggested and incorporated in the insulator sulator shielding of the rotary capacitor. Since the dee support insulators are subjected to only a small fraction of the dee voltage, the shielding has not been changed on these insulators.

The tests indicate that, with the insulator water and air cooling called for in the present capacitor designs, the maximum permissible continuous peak voltage appearing at the capacitor will lie between 55 and 65 kilovolts. The uncertainty lies principally in the difference between the test air cooling and the air cooling planned for the capacitor.

R. F. voltages greater than 55 to 65 kilovolts will probably result in considerable heating of the insulators. It is not known how far one may go in this direction, for it was not possible to test the ultimate limit of the insulators. The new alumina insulators will probably stand appreciably higher temperatures than the zircon insulators.

The rotary capacitor is designed for .080" blade separation and blade edge radii of .065" to .075". The tests have shown that these gaps and radii will hold a maximum of 45 to 50 kilovolts peak r.f. Further, the importance of all blades having proper radii has been demonstrated. It seems likely therefore, that with the present dimensions, gap breakdowns will present a lower limitation to the voltage than will the insulators.

The maximum safe dee voltage during the modulation cycle is greater than the limitation imposed by either the insulators or gap breakdowns; the voltage appearing at the capacitor will be one half to one third the dee voltage at the low frequency end of the cycle. An increasing dee voltage can therefore be used during the acceleration cycle. The maximum allowable values of dee voltage depend upon the details of the frequency range and voltage relations.

MDDC - 474 A Study of Electron Collection in a Parallel Plate Ionization Chamber, by R. Sherr and R. Peterson. 31p.

With a parallel plate ionization chamber and a fast amplifier to reproduce the pulse resulting from electron collection, it is possible to measure the energy of an ionizing particle, and the angle which its path makes with respect to the electrical field of the chamber if the particles' path is wholly within the chamber. The initial slope of the pulse is a measure of the total charge in the track. As the electrons drift to the positive collecting electrode, this initial slope is maintained until the track strikes the collector. At this instant the slope starts to decrease, finally reaching zero when the track has disappeared. This time interval (of changing slope) is related to the length of the track and to the angle between the track and the field. By appropriate measurements on the pulse it is therefore possible to find the angle of the track as well as its energy for nuclear processes possessing an axis of symmetry (e.g., neutron scattering). This angle and the energy are sufficient to determine the process if the axis of symmetry coincides with the direction of the field. Tests, both photographic and electrical, have been made which verify the above conclusions.

MDDC - 475 Theory of ion chambers, by Thoma M. Snyder. 13p.

A simple method for calculating the shape of electrical pulses induced in ion chambers by the collection of single ion tracks is established; then this method is applied to plane, cylindrical and spherical chamber geometries. From the results obtained, the proper use of these various chambers becomes clear and some new methods of application are suggested.

MDDC - 476

A Calorimetric Determination of the Energy Produced by Plutonium-239. by J. W. Stout and W. M. Jones. 14p. (See also Physical Review, Vol. 71, p. 582-585, May 1, 1947).

The rate of energy production by alpha-disintegration of plutonium-239 has been measured calorimetrically. The method was to measure the rate of evaporation of liquid nitrogen by a 120-gram sphere of metallic Pu-239 and compare this rate with that produced by the introduction of electrical energy. The power produced by Pu-239 is 1.923 $\pm$ .019 abs. watts gram^{-1}. Combining this with energy per alpha particle determined from range and range-energy measurements, one obtains 2.411 x 10^4 years as the half-life of Pu-239 with respect to alpha emission.

MDDC - 477

Discovery, Identification, and Characterization of 2.8d Ru^{97}, by W. H. Sullivan, N. R. Sleight, and E. M. Gladrow. 3p. (See also Physical Review Vol. 70, p.778, November 1946).

The assignment of 2.8d Ru to mass 97 was based on the following considerations. By slow neutron activation only radio-isotopes Ru^{97}, Ru^{103}, and Ru^{105} would be produced. The 4.5h Ru $\rightarrow$ 36.5h Rh decay chain, which was formed in slow neutron and deuteron-irradiated Ru and which was found to emit only negatrons, was assigned to mass number 105, since no other mass assignment would permit chain decay by negatron emission. The assignment of the 42d isotope to mass number 103 was based; 1) on Livingood's observation that a 46d activity in deuteron-bombarded Ru emitted only negatrons; 2) on observation that these negatrons were nuclear beta radiations; 3) on arguments concerning the observed gamma ray intensity ratio, $I_{2.8d}/I_{42d} \sim 2$, at the end of the bombardment. Using the assumption that the activation cross-sections for Ru^{96} and Ru^{102} did not differ greatly and that the bombardment time was effectively "infinitely short", it was found that the observed and predicted ratios were in much closer agreement for the assignments 2.8d Ru^{97} and 42d Ru^{103}, than for the assignments, 42d Ru^{97} and 2.8d Ru^{103}.

From the foregoing facts, observations, and deductions, the most probable decay process for Ru^{97} appeared to be K capture since the X-ray/γ-ray ratio of ~ 4 and the presence of low energy electrons ($\sim$0.2 Mev) pointed to partial conversion of the 0.23 Mev γ-ray rather than low energy positron emission, which could be the alternate mechanism. Also, the 18.2 Kev X-ray energy corresponded to that expected for element 43 formed by K electron capture in Ru.

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MDDC - 477 Discovery, Identification, and Characterization of 2.8d Ru^{97}, by W. H. Sullivan, N. R. Sleight, and E. M. Gladrow. 3p. (See also Physical Review Vol. 70, p.778, November 1946). (Cont'd from page 284).

A search for the daughter 43 activity of the 2.8d Ru did not give conclusive results since 42d Ru^{103} contaminated the element 43 fraction, isolated as the tetraphenyl arsonium salt. However, the data indicated 43^{97} must be long-lived and from absorption measurements in a windowless counter there was some evidence that a very soft beta ray was present. It was considered possible that this radiation was due to the 0.097 Mev electrons from the 90d isotope discovered by Cacciopuoti.

MDDC - 478 The Radiography of Heavy Radioactive Metals, by G. H. Tenny 19 p.

The various experiments to determine best method of making radiographs of uranium are described. The production method at present in use employs a radium-bromine cylinder (2514.4 mg. Ra) as the source and the following film and screen combination in order: Pb filter 0.020 inches, Patterson intensifying screen #353, Eastman Kodak Type A film, Patterson intensifying screen #353, Pb screen 0.020 inches, Eastman Kodak Type A film, Pb screen 0.020 inches, and 1/4 in. Pb shield.

This method proves to be satisfactory for the required purposes. In using penetrometers on the actual objects, a resolution of $2\frac{1}{2}\%$ up to a thickness of 4 inches was achieved. Since the only defects possible are mostly air bubbles, this method is able to detect them.

The screen- and film combination described makes it also possible to inspect pieces of various thicknesses at the same time.

The method is far from being the ultimate one. There are two problems to be solved: 1) Due to the relatively large size of the source, the penumbra effect influences the resolutions. This could be avoided in using smaller sources such as the betatron. 2) The exposure time is a relatively long one which could be eliminated in using stronger sources such as betaron again, or certain types of isotopes.

MDDC - 479 Reaction and Scattering Cross Sections, by E. P. Wigner 7p. (See also Proceedings of the National Academy of Sciences Vol 32 p. 302-306 December 1946)

A review is given of two previous papers in which an attempt was made to give a formulation to the resonance theory of nuclear reactions which would be free from artificial assumptions. This theory deals with reactions in which two nuclei collide and either reseparate without any change (elastic scattering) or undergo a reaction so that the pair separating after the collision is different from the colliding pair (nuclear reaction or excitation).

The following arguments based on assumptions concerning the wave function of the compound nucleus, two statements are introduced for consideration and again reference is made to a preceding paper:

(I) That the elastic scattering cross section does not vanish in general for any value of the energy, except in one alternative reaction.

(II) The reaction cross section vanishes for discrete values of the energy in two alternative reactions. In three and more alternative reactions, no reaction cross section (and because of (I) no scattering cross section) vanishes in general for any values of the energy.

A proof is given for (I) and (II) which is independent of the formalism previously employed in the reference papers. At the same time the proof generalizes (I) and (II), inasmuch as the assumption of zero angular momentum of the colliding particles is not employed.

MDDC - 480 Slow Neutron Velocity Spectrometer Studies III—I, Os, Co, Tl, Cb, Ge, by C. S. Wu, L. J. Rainwater, and W. W. Havens, Jr. 28 pp. (See also Physical Review Vol. 71 p. 174-181, February 1, 1947)

The 1/v thermal line for Iodine is $\sigma = [(3.8 \pm 0.2) + (1.12 \pm 0.05)E^{-\frac{1}{2}}]$. Crystal interference effects are apparent at low energies. There is a resonance at (20.6 ± 0.4) ev. with $\sigma_0 \Gamma^2 \sim 4$. A flat bottomed dip at 37 ev. suggests two levels at (32 ± 2) ev. and (42 ± 2) ev. with approximately equal values of $\sigma_0 \Gamma^2 \sim 135$.

The 1/v thermal line for osmium is $\sigma = [(15 \pm 0.4) + (2.7 \pm 0.1)E^{-\frac{1}{2}}]$ with crystal interference effects at low energies. There are levels at (6.5 ± 0.3) ev. with $\sigma_0 \Gamma^2 \sim 10$, at (8.8 ± 0.3) ev. with $\sigma_0 \Gamma^2 \sim 35$, at (20 ± 1) ev. with $\sigma_0 \Gamma^2 \sim 25$, probable levels at (28 ± 1.5) ev. with $\sigma_0 \Gamma^2 \sim 8$, at (42 ± 2) ev. with $\sigma_0 \Gamma^2 \sim 10$, at 84 ev. and several unresolved levels above 84 ev.

The 1/v thermal line for cobalt is $\sigma = [(6.7 \pm 0.3) + (6.4 \pm 0.15)E^{-\frac{1}{2}}]$. There is an unusually strong dip at (115 ± 5) ev. with $\sigma_0 \Gamma^2 \sim 200{,}000$ (if single) and indications of other strong unresolved levels in the region of 1,000 to 10,000 ev.

The 1/v thermal line for thallium is probably $[\sigma = (9.7 \pm 0.2) + (0.6 \pm 0.2)E^{-\frac{1}{2}}.]$ There are strong crystal interference effects at low energies. There is a strong dip in the transmission curve at 270 ev. and another broad dip near 1100 ev.

Columbium shows only a slight 1/v effect $\sigma = [(6.4 \pm 0.2) + (0.10 \pm 0.04)E^{-\frac{1}{2}}]$ with strong crystal interference effects at lower energies. Only a slight dip at 4.1 ev. attributed to a slight Ta impurity was found in the higher energy region.

Germanium shows no 1/v thermal slope because of the strong crystal interference effects. There is a (perhaps multiple) level at 95 ev. with $0_0 \Gamma^2 \sim 800$.

MDDC - 481 **Hyperheparinemia - the Cause of Hemorrhagic Disease Produced by Total Body Exposure to Ionizing Radiations, by J. Garret Allen, Margaret Sanderson, and Leon O. Jacobson.**

1. The hemorrhage disease in dogs given a single lethal total body exposure to X ray (450r) is characterized by a prolonged clotting time.

2. No defect of the known elements of clotting was demonstrable except for a reduction in the platelet number and the appearance of an anticoagulant not normally present in detectable quantities.

3. The thrombocytopenia per se does not appear to be the important factor responsible for the disease because the bleeding may occur before the platelets are reduced and transfusions of fresh citrated whole blood did not prevent or stop hemorrhage. Moreover, the factors that specifically inhibit the anticoagulant, restored the clotting time to normal, but did not prevent thrombocytopenia or elevate the platelet count.

4. The anticoagulant reacts like heparin in all respects tested. Its activity was destroyed by specific antiheparin substances such as protamine, toluidine blue and other dyes of the thionin series.

5. Toluidine blue prevented hemorrhage in dogs after X-ray exposure and stopped hemorrhage once it appeared.

6. The authors were able to isolate from the blood of dogs in the state of hemorrhage an anticoagulant, which on the basis of unit potency per mg. of weight, was as active as the standard sodium acid salt of heparin.

7. The administration of large quantities of vitamin K and vitamin C were ineffective in preventing or stopping hemorrhage.

8. Toluidine blue was ineffective in preventing or curing the hemorrhagic disease produced in normal dogs given dicumarol.

9. Thrombocytopenia, neutropenia, and anemia were produced in normal dogs by the administration of a nitrogen mustard. The whole blood clotting time was not prolonged and hemorrhage did not occur.

10. The hemorrhagic disease associated with over exposure to X ray was closely correlated with infection. The suggestion was made that the anticoagulant was bound to the immune proteins and was released when the antibodies were exhausted or destroyed. The administration of high titre anti-sera and antitoxins prevented hemorrhage and prolonged the lives of the two dogs in which they were used.

MDDC - 482 **Manganese, Rhenium, and Masurium (Analytical Chemistry of the Manhattan Project, Chapter XXXII), by R. W. Bane and C. J. Rodden 12 p.**

The chief material analyzed for manganese was uranium metal where it occurred in trace amounts. Some determinations in alloys and other materials were also made. Masurium was of interest in fission products, while rhenium has been of but minor interest.

Volumetric and colorimetric methods are given for determining manganese in uranium as is a counting method for the determination of radioactive masurium, utilizing the distillation of the oxide from perchloric acid solution into sodium hydroxide, and the precipitation of the radioactive masurium with Re_2S_7 as a carrier.

The determination of rhenium was not necessary for routine control. One is able to determine 25 ppm in uranium base materials by spectrographic means. A colorimetric method based on extraction of the thiocyanate-complex by amyl alcohol was used for uranium base materials.

MDDC - 483 **Titanium, Zirconium, and Hafnium (Analytical Chemistry of the Manhattan Project, Chapter XXXV), by R. L. Barnard and R. E. Telford 22 p.**

The determination of titanium, zirconium, and, to a lesser extent, hafnium has been of interest on the Project because of the presence of these elements as impurities in uranium metal, uranium compounds, and graphite ash, and also because of work done with alloys of uranium with zirconium at the Metallurgical Laboratory.

Except for spectrographic methods, the usual occurrence of titanium as a trace element in Project materials has limited the choice of analytical methods for this element to spectrophotometric methods.

The hydrogen peroxide method has been most widely used. It is rapid and accurate, and has but few interferences, most of which were inconsequential in pure uranium materials.

The dihydroxymaleic acid method is more sensitive than the hydrogen peroxide method and offers the advantage that vanadium does not interfere.

The use of disodium 1,2-dihydroxybenzene-3,5-disulfonate permits the determination of titanium in the presence of a large excess of uranium.

Spectrographic methods are useful because they generally require only group separations and it is possible to determine several additional elements simultaneously.

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MDDC - 483

Titanium, Zirconium, and Hafnium (Analytical Chemistry of the Manhattan Project, Chapter XXXV), by R. L. Barnard and R. E. Telford. 22p. (cont'd from page 289).

Two types of problems were presented in the analysis of Project materials for zirconium. One of these dealt with the analysis of impure materials and alloys in which large amounts of zirconium were to be expected. The other involved trace analyses of pure uranium metal and uranium compounds, and of process solutions.

For macro analyses gravimetric methods were employed. Cupferron and phenylarsonic acid were used as precipitants, and in both cases the precipitate was ignited and weighed as zirconium oxide. Micro determinations were performed spectrophotometrically using either alizarin or p-dimethylaminoazophenylarsonic acid as color reagents. Spectrographic methods were also developed.

Hafnium has been determined in Project materials only in a few cases when spectrographic examination of cupferron group concentrates included an estimation of hafnium along with the other constituents of the concentrates.

MDDC - 484

Some Aspects of the Biological Action of Radiation, by E. S. G. Barron. 13p.

This is a summary of a lecture given at the University of San Marcos, Lima, Peru, covering the effects of radiation on enzymes, the changes observed in the blood proteins of dogs treated with X-rays, the effects of X-rays on the metabolism of tissues of rats, the effect of X-rays on the metabolism of the small intestine, on the permeability to glucose, and on the phosphorylation of fructose.

MDDC - 485 **Certain Neutron Properties of Materials - 1, by H. H. Barschall, E. Graves, J. H. Manley, and V. F. Weiskopf. 41 p.**

Measurements are being made of the transport cross section for fast neutrons of various energies in various materials. This is the first of a series of reports in which the results are to be reported and discussed. It includes measurements of back scattering and poor geometry transmission scattering for neutrons of 1.5 and 3 Mev. Results are tabulated.

MDDC - 486 **Certain Neutron Properties of Materials - II, by H. H. Barschall and J. C. Coon. 17 p.**

In MDDC - 485, back-scattering and poor-geometry transmission scattering measurements were described for neutrons of 1.5 and 3 Mev. In the present report further experiments at 3 Mev are described, and also similar measurements for neutrons of 600 Kev energy. Results are plotted and tabulated.

MDDC - 487 Certain Neutron Properties of Materials - III, IV, V, by H. H. Barschall 29 p.

Measurements of the scattering of various materials for neutrons of 200 kev energy are described. The results of measurements on addditional materials at 1500 kev and 3000 kev are also given. Data tabulated.

MDDC - 488 Histopathology of Irradiation from External and Internal Sources, by W. Bloom 417 p.

This is a comprehensive detailed account of the effects of the different types of radiation on the various organs of laboratory animals. Subjects covered include materials and methods, the cell, the skin, bone, bone marrow, spleen, lymph node and intestinal lymphatic tissue, thymus, gastrointestinal tract, liver, ovary, kidney, pancreas, testis, vascular system, adrenal, and nervous system.

MDDC - 489 Range Measurements of 94^{239} and 94^{238}, by O. Chamberlain, J. W. Gofman, E. Segre, and A. C. Wahl. 4p. (See also Physical Review Vol. 71 p. 529-530 April 15, 1947).

The ranges of alphas from 94^{239} and 94^{238} have been measured by comparison with Po alphas, and are found to be 3.68 and 4.08 cm of air.

MDDC - 490 The Heaviest Elements and Fission Products, by J. G. Hamilton 2 p.

A study has been made of the metabolism in the rat of the heaviest elements and of fission products. The heavy elements studied include thorium, protoactinium, neptunium, plutonium, and americium, and the fission products investigated were radioactive isotopes of strontium, yttrium, zirconium, columbium, ruthenium, tellurium, iodine, xenon, cesium, barium, lanthanum, cerium, and praseodymium. In addition, a rather detailed investigation of the metabolism of an unseparated mixture of uranium fission products was undertaken. The result of these studies indicated that these heavy elements are absorbed to a very small degree by way of the digestive tract, deposited primarily in the skeleton following parenteral administration, and eliminated very slowly. The metabolism of plutonium in two human subjects was investigated and found to be comparable to the behavior of this radio-element in the rat.

The most significant conclusions that can be derived in the survey of the work done with the long-lived fission products can be summarized in the following manner: strontium, barium, yttrium, lanthanum, cerium, praseodymium, zirconium, and columbium, when introduced into the body, are deposited primarily in the skeleton where the average degree of retention of the absorbed radio-elements is approximately 50% of the initially absorbed quantity. The retained fractions of these radio-elements are eliminated at rates which are less then their rates of radioactive decay with the exception of the 340 day cerium and possible strontium 90. The remaining five long-lived radio-elements, ruthenium, tellurium, xenon, iodine and cesium do not show any significant degree of localization in the skeleton and in addition, there is no very striking

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MDDC - 490 The Heaviest Elements and Fission Products, by J. G. Hamilton
(cont'd from page 293).

deposition in any other of the tissues, with the exception of the deposition of iodine in the thyroid. The rates of elimination for all of these five radioelements are much greater than their rates of radioactive decay, with the exception of iodine accumulated in the thyroid. In this particular case, the release of accumulated iodine in the thyroid is many times slower than its rate of radioactive decay. The members of the long-lived fission product group which are absorbed by way of the digestive tract include strontium, barium, tellurium, iodine, and cesium.

Radioautographic studies of the deposition of yttrium, zirconium, cerium, uranium, plutonium, and americium in bone, indicate that these materials are selectively accumulated in the osteoid matrix.

MDDC - 491 Mass Spectrometric Observation of C^{14}, by M. G. Inghram 7 p.

A sample of $BaCo_3$ containing beta emitting radioactive C^{14} prepared by the reaction $N^{14}(n,p)C^{14}$ was studied with a Nier type mass spectrometer. The investigation was undertaken to verify directly with the mass spectrometer, that the mass of the long-lived radioactive carbon isotope is 14, and to measure the abundance of that isotope so that a determination of the half life of the long-lived radioactive carbon can be made.

The $BaCO_3$ sample was made to evolve CO_2 for mass spectrometric analysis by heating it in a quartz tube to about 1100°C.

After the carbon dioxide sample was obtained at about 10 cm pressure it was transferred to the sample system of a Nier type mass spectrometer, and allowed to leak slowly into the ionization region of the spectrometer. There it was ionized, and the ions were collimated and accelerated into a 60° six inch radius of curvature, magnetic analyser. The analysed beam was collected and amplified by a direct coupled, 100% inverse feedback amplifier. The output of the amplifier was recorded by a 4 second Brown electronic strip chart recorder of standard design. Sweep of the ion beams across the collector was accomplished by using an automatic electronic variation of the analyser magnetic field current. This automatic sweep was adjusted to repeat itself automatically after it had covered the range of masses desired. All mass spectrometer discriminations were minimized by a careful adjustment and measurement.

The percentages determined were C^{14}, 3.35 + .03%; C^{13}, 1.04 + .01%; C^{12}, 95.61 + .03%.

Thus a direct mass spectrometric verification of the mass of the long-lived radioactive carbon isotope was made, and with the aid of the abundance measurement of the C^{14} in this material a half life for C^{14} can be deduced.

MDDC - 492 Chromium, Molybdenum, and Tungsten (Analytical Chemistry of the Manhattan Project, Chapter XXXIII), by K. J. Jensen and B. Weaver. 23p.

The most widely used method for determining macro amounts of chromium in Project materials has been the reduction of chromium (VI) with standard ferrous sulfate solution. With various modifications it has been used for numerous kinds of samples, including many containing uranium. In the procedure used at several of the sites chromic ion is oxidized to the sexivalent state in an acid medium by ammonium persulfate in the presence of silver ion. The chromium is estimated by adding an excess of standard ferrous sulfate solution and back-titrating with standard permaganate or ceric sulfate solution, using ferrous phenanthroline complex, ferroin, as an indicator. This procedure is subject to few interferences. However, any substance which is reduced by the ferrous sulfate solution and not reoxidized rapidly by the ceric sulfate will interfere with the analysis. Some interference of this type, for example, maganese, can be eliminated by addition of a reducing agent such as sodium azide or dilute hydrochloric acid which preferentially reduces the permanganate. After the excess persulfate has been destroyed, sodium azide or dilute hydrochloric acid is added and the solution is boiled a short time.

Vanadium is a disturbing element, since it is oxidized to the vanadate state (VO_3^-) by the persulfate and reduced by the ferrous sulfate to the vanadyl state (VO^{++}). The vanadyl ion is slowly reoxidized to the vanadate state by the ceric sulfate, causing a constantly fading endpoint. Although the titration to a permanent endpoint is possible, large amounts of vanadium should be separated from the chromium. This can be done by precipitating vanadium cupferrate from a strongly acid solution with a pH between 1.2 and 1.6. In the procedures involving titration with permanganate, vanadium does not interfere.

The production of an intense color by chromate ion with sym-diphenylcarbazide was first observed in 1900 and has been the subject of many investigations since that time. This very sensitive and selective reagent has been very widely used for the determination of small amounts of chromium in uranium materials and process solutions. Much work has been done at various Project laboratories in adapting this reagent to their special needs.

Macro amounts of molybdenum can be determined by both gravimetric and volumetric methods. The gravimetric methods commonly used on the Project include precipitation of the molybdenum as lead or molybdenum sulfide, or as the molybdenum complex of α-benzoinoxime. The lead molybdate precipitate is ignited and weighed as such while molybdenum sulfide or the molybdenum complex with α-benzoinoxime is ignited to the oxide and weighed.

The volumetric determination of molybdenum, after its separation as volatile $MoO_3.2HCl$ or insoluble thorium molybdate and subsequent reduction in a Jones reductor, has been employed by the Ames group The simultaneous titration of uranium and molybdenum was found to be unreliable.

Colorimetric methods based on the colored compounds molybdenum forms in the presence of thiocyanate and of phenylhydrazine have been used in the Project analytical laboratories. Procedures using the thiocyanate complex have been most commonly used.

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MDDC - 492 Chromium, Molybdenum, and Tungsten (Analytical Chemistry of the Manhattan Project, Chapter XXXIII), by K. J. Jensen,and B. Weaver 23 p. (cont'd from page 295).

Tungsten is precipitated quantitatively by α-benzoinoxime. In a British method use is made of this fact in the micro determination of tungsten. Molybdenum and tungsten are precipitated together with α-benzoinoxime, ignited, and fused with a flux. The melt is dissolved in water and made acid with sulfuric acid. A reducing agent (thioglycollic acid) and potassium thiocyanate are added. The resulting colored molybdenum complex is extracted with butyl acetate and tungsten is determined in the remaining aqueous solution.

Tungsten is usually precipitated as tungstic oxide and weighed as such. For tungsten-uranium alloys the Ames laboratory obtained sufficiently accurate results by simply dehydrating the solution with perchloric acid and igniting and weighing the precipitated oxide. In some cases where interfering substances such as chromates, molybdates, and sulfates are absent, tungsten can be precipitated as mercurous tungstate and ignited to tungstic oxide.

The blue color of the tungsten complex with toluene-3, 4-dithiol has been applied to the determination of traces of tungsten in uranium materials by a British group. This method requires a preliminary separation with α-benzoinoxime followed by removal of the molybdenum.

MDDC - 493 Minimum Hydrogen Peroxide Concentration Required for Precipitate Formation from 50 Per Cent Uranyl Salt Solutions, by R. Livingston 2 p.

The purpose of this study was to estimate the minimum hydrogen peroxide concentrations required for formation of a precipitate in 50 per cent solutions of uranyl nitrate and uranyl sulfate (per cent based on weight of anhydrous salt) containing various concentrations of excess anion as acid.

Thirty-six tests were carried out simultaneously in 3 ml corked Pyrex test-tubes at room temperature. In each test 2 ml of the 50 per cent uranyl solution was placed in the tube and the proper volume of 70 per cent nitric acid or 96 per cent sulfuric acid was added to give the per cent by weight of additional acid indicated in the table. Chemical analysis showed that the uranyl sulfate solution initially contained 0.26 per cent free sulfuric acid, while a less satisfactory analysis of the uranyl nitrate indicated essentially no free acid. Six dilutions of "Superoxol" H_2O_2 solution were standardized iodometrically for H_2O_2. H_2O_2 was introduced into the test solution by addition of 0.1 ml of one of the diluted H_2O_2 solutions to give the concentrations indicated in the table. In each case, a precipitate formed (sometimes only momentarily) on addition of H_2O_2, due to local saturation. Results are given after the tubes had been shaken and allowed to stand for 3 hours. After several days the only change noted was a decrease in the opalescence in some of the tubes accompanied by the formation of more precipitate. The results indicate that the threshold concentration of H_2O_2 for precipitated formation is higher for nitrate than for sulfate, and is raised by the addition of excess acid. Results tabulated.

MDDC - 494 **The Visocosity of Gaseous Uranium Hexafluoride, by A. L. Myerson and J. H. Eicher 37 p.**

A series of experiments was undertaken to investigate the reason for the large (10 to 20%) discrepancies between values of the viscosity of gaseous UF_6 reported by R. D. Fowler in the United States and by Llewellyn, Swaine, and Roberts in Great Britain. All investigators used the method of capillary flow to measure the ratio of the viscosities of UF_6 and air. It was found that with small diameter metal capillaries the apparent value of this ratio may vary with Reynolds Number even down to Reynolds Numbers as low as 10. The values finally determined for the viscosity of UF_6 in the range 40 to 200°C agree well with those of Llewellyn, Swaine, and Roberts.

MDDC - 495 **5.3 Solubility of Xenon and Nitric Oxide in Various Solvents, by R. A. Penneman 3 p.**

The solubility of xenon in air-free carbon tetrachloride was determined. Nitric oxide solubilities were measured in aqueous solutions of various reagents.

XENON AND NITRIC OXIDE SOLUBILITIES

Gas	Temp., °C	Solvent	l*	Remarks
Xe	31	H_2O	0.097	Lit. values 0.100, 0.107
	28	CCl_4	2.4	
	31		2.3	
	31		2.9	
	32		2.4	
NO	32	CCl_4	0.380	Lit. value 0.37
	32		0.387	
NO	30	20 g CrO_3 in 100 g 40 percent H_2SO_4	60	End soln. showed complete reduction to Cr^{+++}. No ppt. formed.
	30		57	
	31	25 g $FeSO_4$ in 100 g H_2O	9.0	NO causes some oxidation to Fe^{+++}
	31		9.4	
	27	15 g $FeSO_4$ in 100 g 2.25	7.2	NO readily expelled
	30	$\underline{N}$ H_2SO_4	6.6	to yield originial
	31		6.8	soln.
	28	33 g $Fe_2(SO_4)_3$ in 100 g 2.25 $\underline{N}$ H_2SO_4	0.2	

* $\underline{l}$ = Ostwald solubility coefficient

MDDC - 496 **Accumulation and Distribution of Radioactive Strontium, Barium-Lanthanum, Fission Mixture and Sodium in Goldfish, by C. L. Prosser, Wm. Pervinsek, J. Arnold, G. Svihla, and P. C. Tompkins 39 p.**

Small non-feeding goldfish accumulated radioactive strontium, barium-lanthanum, fission mixture elements and sodium from solution in which they were immersed. Accumulation was rapid initially and continued at a rate greater than the loss of radioactivity in the medium by decay and adsorption. Hence, the ratio of the concentration of active material in the fish to that in the solution increased with time. After a few days this concentration ratio was usually between 10 and 100. The concentration ratio was independent of dose over the range investigated (0.01 μc to 1.0 μc/ml).

Calcareous tissues, such as skeleton and scales, accumulated about 75 per cent of the radio-strontium and radio-barium in the whole fish. Lanthanum and a mixture of cerium, yttrium and zirconium-columbium appeared to be accumulated in visceral tissues, especially the intestine, and to be more actively adsorbed on feces and glass than were the alkaline earths. The comparable distribution, particularly of bone-seekers, on immersion and injection indicated that these elements were taken up through gill and oral membranes and were distributed by the blood. Radio-sodium was present in greater proportion in the gills at six hours than later. Fission mixtures shifted in abundance from soft parts to bony portions of the gills during the first few days. Injection experiments indicated that there was no fecal excretion of strontium but that there was a small amount of fecal excretion of Ba^{140}-La^{140} and of fission mixture. Some fission mixture components appeared to be taken out of the medium, either from feces or water, and precipitated along the intestinal folds. The yolk of eggs in ripe ovaries accumulated some components of fission mixture but not strontium or barium. Young growing or regenerating bone accumulated more radioactive material than did older bone; cartilage accumulated none of the bone-seekers. Large mature goldfish accumulated radioactive material more slowly than did small fish. This may have been in part related to their calcium turnover. Uptake of $strontium^{89}$ and uptake of fission mixture were shown to be greater when the surrounding pond water was low in calcium (1.8 p.p.m.) than when it was high in calcium (36 p.p.m.). Inactive strontium also retarded the uptake of radio-strontium.

When the fish were transferred from active to inactive pond water they lost some Ba-La and fission mixture radioactivity from soft tissues during the first few hours but they did not lose the major part of their radioactivity any faster than by decay alone. The rate of loss of radio-strontium appeared to be unaffected by the calcium content of the water.

Goldfish were unable to desorb any appreciable quantities of fission elements from suspended clay.

MDDC - 497 Photographs: 184 in. - 27, 41, 198, 252, 271, and Cyclo - 74, by Radiation Laboratory, Berkeley, California 6p.

This document consists of 6 photographs of the 184 in. Berkeley cyclotron.

MDDC - 498 Additivity of Lethal Effects of External Beta and Gamma Irradiation, by J. R. Raper, and K. K. Barnes. 11p.

Analysis of the survival of mice following added doses of external beta rays and gamma rays demonstrate that the acute lethal effects of the two radiations are not completely additive. Four series of experiments were performed; the results of two series indicate partial additivity of effects while the other two series indicate complete independence of action of the two radiations.

MDDC - 499 **Effects of Total Surface Beta-Irradiation, by J. R. Raper. 21p. (See also Radiology Vol. 49, p.314-324, September 1947)**

In order to explore fully the effect energy absorption distribution on biological effect, a series of laboratory animals including baby rats (one day-old), mice, rats, guinea pigs, and rabbits were exposed at graded doses in sufficient numbers to establish the pattern of effects in each species.

Due to the superficial absorption, irradiation with beta rays in doses below the acute lethal range results in greater gross and superficial damage than that following irradiation with more penetrating X-or gamma rays. The pattern of gross damage can best be shown by the incidence of the various effects, with time following irradiation, in a group of animals which received identical dose. A single dose of 4000 rep, delivered in about an hour, first produces visible damage in mice about a week after irradiation, at which time the eyelids become inflamed, the eyes watery and, in a large percentage of individuals, sealed shut. A few days later epilation around the eyes and snout becomes evident and by the end of three weeks all animals are similarly and conspicuously affected. A slight erythema on the feet and ears affects about a third of the animals during the second and third weeks after which it disappears. Hyperemia and subsequent drying of the ear tips first appears during the third week and later affects most of the animals; recovery is complete in most cases but there is the complete loss of the tips of the ears in a few individuals. Extensive, and frequently severe, epilation over the entire trunk of the animal begins during the fourth week after irradiation and persists for many months. Concurrent with epilation there may be local desquamation and the ulcerated areas thus produced frequently persist until the death of the animal.

Lower doses of beta rays produce in mice essentially the same effects as those discussed for the range 4000-5000 rep but in lower incidence and of less severity. The early effects of higher doses are identical with those in the 4000-5000 rep range but paradoxically develop somewhat more slowly and death occurs before many of the symptons are manifest. After doses of 10,000-15,000 rep few of the animals show any superficial effect other than watery or closed eyes at the time of death 10-20 days after irradiation.

In rats the effects of beta irradiation are similar to those described for mice. Two important differences have been noted, however: 1) to produce comparable damage in the two species a higher dose, almost double, is required for the rat; and 2) the region of most severe epilation and ulceration is characteristically different. In case of the rat, the head, a medial dorsal band along the spine, and the base of the tail are particularly sensitive.

Guinea pigs are less seriously affected than any of the other species studied. At doses in the acute lethal range the surviving animals showed extensive and severe epilation, but there was no ulceration or loss of ear tips.

Total surface beta irradiation effects an acute lethal action in each species at a characteristic dosage. The main wave of mortality occurs at a somewhat later post-irradiation time than following irradiation with X- or gamma rays and for lethal studies with beta rays 45 days has arbitrarily been chosen to define a survivor in contrast with the 21 day survival commonly used for X- and gamma rays. With graded doses percentage and survival of each species

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MDDC - 499 Effects of Total Surface Beta-Irradiation, by J. R. Raper. 21p. (See also Radiology Vol. 49, p. 314-324, September 1947) (Cont'd from page 300).

produced a sigmoid curve typical of the curves relating biological effects with dose of ionizing radiations. The critical dosage ranges, as measured in air at the surface of the animal, varied roughly as the size of the animal. The median lethal dose, or LD_{50}, for each species, the dose required to kill 50% of the animals within 45 days after exposure, was found to be as follows:

Baby rats	2200 rep
Mice	4700 rep
Rats	7500 rep
Guinea pigs	7750 rep
Rabbits ca.	17,000 rep

In making comparisons gamma rays are 1.75 times as effective in producing lethal action as beta rays.

MDDC - 500 Gross Effects of Beta Irradiation on Restricted Surface of Rabbits, by J. R. Raper, J. E. Wirth, K. K. Barnes. 18p.

The damage resulting from exposure to external beta rays in doses ranging from 1000 to 30,000 rep to a restricted area on the body surface of rabbits has been followed for nine months after irradiation.

The pattern of the reaction was strikingly similar throughout the dose range 5000 to 30,000 rep. The main effects, in the order of their appearance, were as follows: (1) erythema; (2) pigmentation; (3) epilation; (4) loss of the outer layer of skin, including the remaining hair, through one or more of three processes, (a) simultaneous separation of the superficial layers over the entire treated area, (b) dry desquamation, and (c) wet desquamation; (5) crust formation; (6) healing; and (7) regrowth of hair.

Late ulceration (9 months) following complete healing was observed in a few animals.

The severity of the response of skin to beta irradiation varied with the dose but not in strict proportionality with dose. The time of the appearance of the various stages varied as a function of the dose, the several effects, in general, appearing earlier at high dose levels.

The damage to skin produced by massive doses of beta rays resembled thermal burns but showed two important differences: (1) the various stages in beta rays damage required 4-7 times as long to develop, and (2) the direct action in the

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MDDC - 500 Gross Effects of Beta Irradiation on Restricted Surface of Rabbits, by J. R. Raper, J. E. Wirth, K. K. Barnes. 18p. (cont'd from page 301).

case of beta rays was confined to superficial tissue (epidermis and upper portion of the dermis). The effects of beta rays resembled more closely the acute effects brought about in the skin by other ionizing radiation, X and gamma rays, grenz rays, and cathode rays; particularly grenz rays, the absorption of which is very similar to that of the beta rays used in this study.

The effects of large doses of beta rays on human skin would in all probability differ only little from that observed in rabbits since the absorption in the superficial inert layer in both cases would decrease by only a few percent the dose to the germinal layer of the epidermis and to the upper portion of the derma.

MDDC - 501 Gross Effects of Total Surface Beta-Irradiation, by J. R. Raper and K. K. Barnes. 36p.

Total surface irradiation of mice, rats, and rabbits with beta ray results in conspicuous and characteristic gross damage. Within wide limits of dosage the pattern of effects varies little, while the severity of damage varies roughly with dose. There are only minor differences in the gross damage observed in the different animals.

The outstanding features of the gross response to beta irradiation, in the sequence in which they appear, are as follows: inflammation of the eyelids and erythema on the ears and feet; closure of the eyes; epilation and desquamation around the eyes, mouth, and nostrils; hyperemia and swelling of ear tips (except in rabbit); general epilation over body; desquamation over extensive area, resulting in severe ulceration; healing; and limited regrowth of hair. Two late effects are frequently observed: late ulceration, involving the breakdown of previously healed skin, and tumor formation.

High doses of external beta rays profoundly affect the weight of the several animals.

The survival time of mice is significantly shortened by doses of beta rays of 3000 rep or more. Two mechanisms are indicated as responsible for lethal action at high and at low dose levels.

MDDC - 502 Rate of Recovery From Total Surface Beta Irradiation, by J. R. Raper, K. K. Barnes. 11p.

The recovery of mice from the effects of total surface irradiation with beta rays has been investigated for a period of 16 weeks following a single exposure. A split dose technique was employed. A conditioning dose was followed at various intervals by graded test doses to determine the recovery of the animals from the effects of the conditioning exposure.

The total dose required in two exposures to produce 50% mortality increased rapidly as the interval between exposures was lengthened. Recovery proceeded very rapidly at first, 1.5 - 2 days and 8 days being required for half and complete recovery respectively. During the period 8 days to 16 weeks, the recovery values exceed 100%, i.e., the conditioning dose imparted a slight immunity against additional exposure.

MDDC - 503 Distribution and Excretion of Plutonium; Chapter VII, Volume 20A, PPR, by E. R. Russell and J. J. Nickson. 18p. decl. 7/7/48.

A brief outline is given of the necessity for protecting the individual worker against an over-accumulation of Pu in the body. Persons working with Pu or in areas where it was handled have submitted periodic urine specimens for analysis which are reported in the survey. From the survey, it is not likely that any individual has accumulated above-tolerance amounts of Pu.

The excretion rate and the distribution of Pu in the various tissues have been determined for at least one fairly normal human. The rate of excretion of Pu in the urine was nearly 0.01% per day of that contained in the body. Observations running beyond 155 days indicate that the excretion rate may be slightly lower after this period.

Precautions are suggested for the exclusion, from the samples, of Pu from the surroundings during collection and handling.

MDDC - 504 Studies of Porphyrin Metabolism II The Effect of Metals on Coproporphyrin Excretion, by S. Schwartz, R. Zagaria. 36p.

The effect of various metals on urine porphyrin excretion has been studied in 116 rabbits. In many of these animals the nearly 3,000 quantitative analyses done have been correlated with studies of total fecal and red blood cell porphyrin, with the ratio of urinary an . fecal coproporphyrin isomers, with urine urobilinogen and routine urinalysis studies, and with weight data.

These studies confirmed the occurrence of a several hundred to several thousand per cent increase of the urine coproporphyrin III excretion in rabbits, injected with lead and of significant increases in their red cell protoporphyrin concentration. These increases persisted for several months. In addition it has been found that certain metals such as thorium, zirconium and lanthanum, which themselves cause no increase in the urinary excretion of coproporphyrin, will produce a marked elevation of urinary porphyrin in animals administered lead several months previously. Since this effect is associated with an increased excretion of lead it is postulated that the mobilized lead rather than the other administered metal is responsible for the increased excretion of urinary porphyrin.

Uranium administered in large doses produces a precipitous drop in excretion of urinary coproporphyrin in both control and in lead-injected rabbits. This effect appears to be due to impaired kidney function. Smaller doses are generally followed by a sustained moderately elevated excretion of coproporphyrin. The injection of arsenic was followed by a considerable increase in porphyrin excretion lasting only a few days. No consistent significant change in porphyrin excretion was found following the administration of beryllium.

Most of the metals studied produced a variable degree of liver dysfunction as indicated by elevated excretion of urinary urobilinogen.

Neither lead nor any of the other metals produced a significant change in fecal porphyrin excretion.

MDDC - 505 Plutonium and Other Transuranium Elements, by G. T. Seaborg. 10p. (See also Chemical and Engineering News, Vol. 25, p. 358-360, 397, February 10, 1947)

This paper deals briefly with the early work done in the discovery and isolation of neptunium, plutonium, americium, and curium. Np has the oxidation states VI, V, IV, and III, with a general shift in stability toward the lower oxidation states as compared with U. Pu has the oxidation states VI, V, IV, and III, with a shift in stability toward III as compared with Np and U. In aqueous solution Am exists only in oxidation state III. Pure $Am(OH)_3$ has been isolated. Cm also exists only in oxidation state III. Cm^{242} can be made by an (n, β^-) reaction with Am^{241}. Cm^{240} is produced by bombardment of Pu^{239} with 44-Mev He nuclei, with the emission of three neutrons. Isolation of pure Cm compounds will be difficult so long as only the short-lived isotopes 242 (5 mos.) and 240 (1 mo.) are available.

MDDC - 506 Hydrodynamic Theory of the Reaction Zone in High Explosives, by T. H. R. Skyrme. 51 p.

The analysis presented here attempts to examine the effect of the reaction zone on the solution of some problems, and especially of the way in which the detonation velocity is reduced below that of a steady plane wave, (the Chapman-Jouguet velocity), by the presence of rarefactions. The subject matter falls into three main parts. The first part deals with stationary detonation waves.

The second part is concerned with the structure of detonation waves of finite age. The most important result obtained here concerns the manner in which the detonation velocity builds up with increasing age; the analysis of this problem was suggested by R. E. Peierls who anticipated the difference between the cases of plane and expanding waves by qualitative arguments derived from the Taylor solutions for the two cases. The last section in this part discusses lateral perturbations of a plane wave; this analysis is helpful in the understanding of the structure of the wave and of the problems discussed in the third part.

The third part deals with the steady state motion attained by a detonation wave in certain cases of two-dimensional flow. The fundamental problem discussed here is the curvature of the detonation front caused by a rarefaction coming from a free surface, and the result is established that the curvature of the detonation front is related to the detonation pressure in the same way as for an expanding wave; this result is reasonable but did not seem quite obvious a priori. By very similar methods there is discussed some cases of steady motion in which the velocity of the stationary system is reduced below the full detonation velocity; these include the cases of a stationary wave traveling in a slab of explosive bound by two plane faces and in a straight cylindrical stick.

MDDC - 507

A Semi-Micro Method for the Simultaneous Determination of Carbon, Fluorine, and Chlorine in Halocarbons, by R. Teston and F. E. McKenna. 19p. (See also Analytical Chemistry Vol. 19, p. 193-196, March 25, 1947)

Carbon, fluorine, and chlorine (and bromine) can be determined simultaneously in halocarbons, which do not contain hydrogen, by a combustion method. After decomposition of the compound at 1000°C in a stream of oxygen, the chlorine reacts with silver in an absorption tube maintained at 295°C (if bromine is present, it reacts simultaneously). Fluorine reacts with quartz to form SiF_4 which is then absorbed on alumina in a tube maintained at 175°C. Carbon dioxide is absorbed by Ascarite as in the conventional carbon and hydrogen determinations. Results obtained with twelve compounds such as C_4Cl_6, $C_4F_6Cl_2$, $C_4Cl_3F_7$ showed fairly good agreement with the truth and indicate that the method will be found useful.

MDDC - 508

Reactions of Human Skin to Single Doses of Beta Rays, by J. E. Wirth and J. R. Raper. 9p.

In determining responses of human skin to beta radiation a distinction must be made between a threshold reaction and threshold erythema. A threshold reaction (mild tanning) can be produced in 80% of those exposed to the beta radiation from a one inch diameter P^{32} contact plaque by a dose of 200 rep, and in only 60% of those exposed to 170 rep. A threshold erythema may be produced under similar circumstances in 80% of those exposed to 813 rep and in 60% of those exposed to 635 rep. A larger number of cases than used here are necessary to determine correct figures within a narrower range.

MDDC - 509 **Five Photographs of the Chain Reacting Pile and Attached Instruments, by Argonne National Laboratory. 5p.**

MDDC - 510 **Photograph of Trace of Start-Up of December 2 Pile, by Argonne National Laboratory. 1p.**

MDDC - 511 Spectrochemical Analysis: (I) The Copper Spark Method, by M. C. Bachelder, J. G. Conway, N. H. Nachtrieb, and A. B. S. Wildi. 27p.

A method of extraordinary sensitivity is described for the determination of thirty elements. A solution to be anlayzed is evaporated on the ends of copper electrodes, which are excited by a condensed spark discharge to produce the impurity spectrum. The method may be applied to the direct determination of impurities in solution, but finds particular application in cases wherein a chemical separation of the impurities precedes their determination.

MDDC - 512 The Slow Neutron Cross Section of Water as a Function of Energy, by R. F. Bacher, C. P. Baker, M. G. Holloway, and B. D. McDaniel 3p.

The slow neutron cross section of water has been measured in the region between 15 ev. and 0.007 ev. with a velocity spectrometer. It is found to increase with decreasing energy quite slowly in the region above a volt, but with increasing rapidity below a volt, to a peak value of 52×10^{-24} cm^2. This is the cross section per H nucleus uncorrected for oxygen.

MDDC - 513 The Slow Neutron Resonance Energies of Au and I, by R. F. Bacher, C. P. Baker, and B. D. McDaniel. 3p.

A preliminary survey of the slow neutron absorption spectrum of Au was made using a thick (3.82 gm/cm^2) absorber. This investigation clearly showed a resonance absorption between 4 and 5 ev.

Iodine was examined in the velocity spectrometer in order to find some evidence of resonance absorption and to find to what energy the transmission remained high. There is strong evidence for resonance absorption with transmission minimum at about 12 μ sec or 36 ev. The width of this resonance absorption is tremendous on an energy scale and is even somewhat greater than that to be expected from the resolution of the apparatus. The two points at short times of flight may be considerably affected by the fast neutron background which decreases after the burst. No reliable measure of this effect has been made since additional shielding was placed around the detector. Previous measurements showed that with less shielding the background was negligible for energies less than 20 ev. (τ = 16 μ sec), and that it was less than 15% for the 9 μ sec point. This fast neutron effect could not possibly account for the observed transmission minimum, but corrections for fast neutrons might somewhat change the shape. The strength of the observed transmission minimum leads one to believe that it represents either a very strong resonance or possibly more than one resonance.

There is no evidence for resonance absorption for neutrons with longer times of flight. The transmission appears to be about 0.9 from 20 μ sec (13 ev) to 80 μ sec (0.8 ev). There appears to be no evidence for any resonance absorption below that indicated at 36 ev.

MDDC - 514 Report on Methods for Analyzing Fluorocarbons, by E. J. Barber, L. L. Burger, and A. V. Grosse. 12p.

I. Analytical Procedure for Determination of Fluorine

The fluorocarbon is fused with sodium metal in a flame ignition Parr bomb. The resulting fluoride is determined by titration with thorium nitrate using sodium alizarin sulfonate as indicator. The titration depends upon the precipitation of the fluoride as thorium fluoride and the subsequent formation of a red lake by a slight excess of thorium nitrate with the indicator.

II. Determination of Molecular Weights of Fluorocarbons

A modified Victor Meyer apparatus was used. To the upper end of the well insulated vapor jacket was attached a reflux condenser and to the bottom a boiling flask was fitted permitting the use of various liquids for different vapor temperatures. Water, ethyl benzene and aniline were used. The bulbs were broken at the bottom of the vaporizing chamber thru the use of a wire hook passing thru a tube just slightly smaller than the bent-over neck of the bulb, all parts being enclosed in the system. Ground glass fittings were employed in the closed system. The displaced air was measured over water.

Due to the high molecular weights of the compounds investigated it was advisable to correct for the volume of liquid and vapor in the bulb to be broken. To make this more precise, the bulbs were sealed under vacuum to eliminate any air that might be otherwise enclosed. The bulbs were drawn from 6 mm pyrex tubing, the body being roughly 3 cm long. On one end was the bent over capillary-size neck and on the other a short capillary for sealing, terminating in another 3 or 4 cm of tubing in which the approximate volume of fluorocarbon was placed.

The bulb wad then attached to a vacuum manifold in an upright position and the air removed allowing the liquid to run thru the capillary into the main body of the bulb. Finally the liquid was warmed gently to the boiling point and the bulb sealed off, both pieces of glass being saved for weighing.

The volume correction was obtained by merely measuring the length of the bulb and applying the proper factor.

Complete saturation of the air displaced was assumed, the small correction for humidity being considered.

A summation of known errors of measurement, gives a value between one and two per cent. For reasonably pure substances, i. e., small boiling ranges, a reproducibility within this figure was found. The vapor pressure correction is uncertain, the extent of saturation being unknown. The correlation between the vapor densities calculated from the perfect gas laws and the formula weights is better than might be expected.

A comparison of results obtained in this report with results obtained using refractometric method (See MDDC-523) is also included.

MDDC - 515 Yield of Photoneutrons from U^{235} Fission Products in Heavy Water, by S. Bernstein, W. M. Preston, G. Wolfe and R. E. Slattery. 15p. (See also Physical Review Vol. 71 p. 573-581, May 1, 1947)

The photodisintegration of the deuteron has been used to study the hard gamma rays emitted by fission products of U^{235}. The neutrons created in the process were used as the indicator of the presence of hard gamma rays. The fission products were placed at the center of a 10" radius sphere of heavy water. Conclusions about the periods and yields of the hard gamma rays were made from the total number of photoneutrons being captured in a large tank of oil surrounding the sphere of heavy water.

Seven half-lives were found: 2.5 sec., 41.2 sec., 2.38 min., 7.7 min., 27.3 min., 1.65 hr., 4.37 hr., and 53 hr. The shortest one and the longest one of these are least reliable. Eighty-five percent of the photoneutrons appear in the two shortest half-lives, the 2.5 sec. component being three times as intense as the 30 sec. component. The total saturated activity of the photoneutrons for an infinite amount of heavy water was calculated from the 10" radius sphere measurements to be about 16.5% of the saturated delayed neutron activity. It is calculated that there must be of the order of one to two photons of energy above 2.2 Mev emitted per fission products with half-lives greater than one second.

MDDC - 516 A Note on the Deposition of C^{14} in Bone, by W. Bloom, H. J. Curtis, and F. C. McLean. 3p.

The autoradiographs of the bones of rats injected with carbon 14 show a markedly different picture from those of the Sr^{89} rats. Those from rats killed three days after injection of C^{14} show the shaft of the bones as black lines. The bone in the epiphysis is a faint grey, while the metaphysis of the growing end of the bone is negative or practically so, leaving a gap of about 2 mm between epiphysis and diaphysis. The non-growing end of the bone is completely outlined in grey. The marrow cavity is so pale that it is probably negative. The autoradiographs of the 2, 4, 8, and 16 week specimens show essentially the same picture as those after three days, except that the bones have grown in length and width. With the growth in length, the unblackened zone at the metaphysis increased to 3-4 mm at 2 weeks, 4 mm at 4 weeks, 10 mm at 8 weeks and 12-17 mm at 16 weeks. Since the blackened lines representing the lateral extent of the diaphysis at the time of injection are still present after 16 weeks, it would seem that the marrow cavity did not increase much in diameter at the site of deposition of radioactive carbon. However, new bone was deposited externally so that the bone as a whole increased in thickness.

Sections of the liver and kidney gave fairly intense autoradiographs at the 3 day and 2 week stages, but were negative after the longer intervals. Since the films were exposed for the same length of time, it would appear that there was approximately as much C^{14} in the bones after 16 weeks as after 3 days, while there was a great decrease in the C^{14} content of the soft tissues.

(Cont'd on next page)

MDDC - 516 A Note on the Deposition of C^{14} in Bone, by W. Bloom, H. J. Curtis, and F. C. McLean.3p. (cont'd from page 311).

From the autoradiographs of bones of these few rats it is concluded that C^{14} injected as carbonate appears primarily in those areas occupied by pre-existing bone. It does not appear in appreciable quantities in the areas of most recently deposited bone salt. This observation demands further study on the carbon metabolism of bone.

Since the C^{14} content of the bones did not decrease appreciably in 4 months, it is believed that the health hazards involved in working with this isotope must be studied. Particular attention should be paid to the possible development of bone tumors.

MDDC - 517 Formation of Focussed Space-Charge-Limited Electrons and Ion Beams, by O. Bunemann, E. U. Condon, A. Latter. 27p.

This report deals with the initial acceleration of intense beams of electrons or ions in such a way as to produce focussed beams. The theory is developed for the cylindrical case in which the emitter is long in one direction. The discussion is written out explicitly for electrons, but is applicable with obvious changes to space-charge-limited positive ion beams. The object of the calculations is to learn how to design the emitting surface and the related electrodes to produce narrowly focussed cathode-ray beams.

MDDC - 518 Separation of Carrier-Free P^{32} from Sulfur, by W. E. Cohn. 2p.

14.3 day P^{32} is produced by the neutron irradiation of elemental sulfur in the Clinton pile. The method described below has been used for the isolation of the phosphorus from the parent sulfur without added carrier or, if more convenient, with the addition of any desired amount of phosphorus carrier.

A volume of concentrated HNO_3, at least twice the volume of the sulfur to be processed, is set boiling over a burner or hotplate. HNO_3 of this concentration is a constant boiling mixture at 120°C. The sulfur to be extracted is melted in a suitable container and poured slowly into the actively boiling HNO_3. Since the sulfur will be at some temperature greater than 120°, which is its melting point, this will result in some super-heating but this can be kept under control by a slow addition of sulfur. The sulfur will form a molten layer at the bottom of the beaker, which is used to contain the mixture, from which droplets of sulfur are continually detached, rising and falling in the HNO_3 phase. After all of the sulfur has been added to the HNO_3, the mixture is allowed to boil another minute or so following which the sulfur is solidified either by simply removing the source of heat or by setting the beaker in water. The HNO_3 phase contains practically all of the P^{32} and may be decanted from the solid block of sulfur. It is of critical importance that the sulfur remain molten during and immediately following its addition to the HNO_3. This cannot be achieved by heating HNO_3 and solid sulfur at atmospheric pressure.

The HNO_3 phase is evaporated to dryness (a small amount of sulfur is oxidized to H_2SO_4 in the extraction step so that a film of H_2SO_4 will remain after evaporation of the HNO_3). The residue is dissolved in warm water, perhaps with the addition of a little HCl, a small amount of Fe or other trivalent cation is added and the hydroxide of the cation is precipitated by the addition of ammonia. The radioactive phosphorus, which now exists as phosphate, precipitates with the hydroxide. This step can be repeated as often as is necessary to remove the last traces of sulfate.

The removal of the cation may be accomplished in one of two ways. If Fe was used to make the hydroxide precipitate, it may be removed by dissolving the precipitate in 9 N HCl and extracting the solution with isopropyl ether saturated with 9 N HCl. This is a standard procedure. However, Fe or whatever cation has been used in the hydroxide step may also be removed by a cation exchanger such as Amberlite IR-1. In either case the phosphorus is recovered as phosphoric acid and has no more inactive phosphorous associated with it than was present in the original sulfur or added in any of the reagents used. The addition of phosphorus carrier for convenience or other reason at any step in the process is optional.

This method has been used with amounts of sulfur ranging from 1 to 500 gms.

MDDC - 519 The Gamma Rays of Po^{210}, by S. De Benedetti and E. H. Kerner. 3p. (See also Physical Review Vol. 71 p. 573, May 1, 1947)

Within the accuracy of the absorption method it appears that the γ radiation of Po consists of a single component of half thickness equal to 8.5 gr/cm^3 Pb. The energy of the radiation can be evaluated to 0.8 Mev. The intensity per curie of Po is equivalent to that of the γ rays from 7.10^{-6} curies of Ra, when both curves are extrapolated to zero absorption.

No evidence of a softer γ component, as reported by Webster and by Bothe and Becker, was observed.

A search for softer radiations showed no other components until, with absorbers thinner than 0.5 gr/cm^2 Al, a radiation was found whose mass absorption coefficient in Al is 18 cm^2/g and which is probably the same component observed by Curie and Joliot and attributed by them to the L line of polonium.

MDDC - 520 Abnormal Isotope Abundance Produced by Neutron Absorption in Cadmium, by A. J. Dempster. 3p.

Mass spectra of samples of cadmium are shown that had been given a prolonged exposure to slow neutrons. The isotope at mass 113 is reduced to approximately one third its normal abundance and the isotope at mass 114 is increased. The change is confined to the surface of the sample as the interior is completely shielded from the neutrons. No change in the abundances of the other isotopes could be detected. These mass spectra confirm the direct measurements reported by Moyer, Peters, and Schmidt (Physical Review, Vol. 69, p. 666, 1946) of neutron absorption by samples enriched in various isotopes, which indicated that the cadmium isotope at mass 113 is the main absorber of slow neutrons.

MDDC - 521 **Energy Distribution near Threshold of Fission Fragments from Np^{237}, by D. H. Frisch. 6p.**

An experiment on fission fragments has been performed with neutrons from the Li (p,n) reaction on an electrostatic generator.

No strong dependence of fission fragment energy distribution was found on bombardment of Np^{237} by neutrons of various energies in the region of fissior threshold.

MDDC - 522 **Instructions -- Leak Detector, Cat. No. 6933950G3, by General Electric Company. 61p.**

This is an instruction manual for the operation of the General Electric Leak Detector which employs a jet of helium and a mass spectrometer to register any helium drawn into the vacuum system.

MDDC - 523 **Refractometric Analysis of Fluorocarbons and Fluorohydrocarbons, by A. V. Grosse. 22p.**

The determination of the fluorine and hydrogen content, or the ratio of F: H atoms, in a fluorohydrocarbon or in a mixture of fluorocarbons and hydrocarbons can be readily achieved by refractometric analysis.

A method is proposed that involves only a measurement of index of refraction (n_D) and density (d). Furthermore, nearly all of the sample can be, and usually is, recovered.

The proposed method is particularly adaptable because both the indices of refraction and densities of fluorocarbons and hydrocarbons are far apart. Furthermore, the specific refraction (r) is even more divergent since it is proportional to some function of n_D and inversely proportional to d.

a) Measurement of n_D

Any instrument that permits the direct measurement of the angle of minimum deflection may be used.

The angle of minimum deflection (α) was determined in the usual way. It was corrected for the reading corresponding to straight transmission (β). In both cases the left side of the image of the slit was brought alongside the cross point of the lines in the eye p'ece.

From the corrected angle of minimum deflection ($\alpha - \beta$), the n_D was calculated from the expression

$$n_D = 2. \sin \frac{60^o + (\alpha - \beta)}{2}$$

Successive readings of the angle could be reproduced to better than $\pm$ 1'.1' corresponds to a difference of 0.0002 units in the index of refraction.

The angle 21°5' corresponds to an n_D = 1.3000, or the lowest reading on the usual type of refractometers. Therefore, if angle ($\alpha - \beta$) is above this value, an ordinary (Abbé) refractometer may be used for measuring indices.

b) Density measurements

The densities were determined by using pycnometers of 2 to 10 cc capacity in the usual way. The density temperature coefficient for fluorocarbons was assumed to equal 0.0008/1°C.

MDDC - 524 Method of Measuring the Drift Velocity of Electrons in Gases, by Donald E. Hudson. 23p.

A method of measuring the drift velocity of electrons in gases has been developed which consists of subjecting a parallel-plate ion chamber to a step function of x-rays. The output is photographed and the response is compared with the theoretical response in order to obtain the drift velocity. Values believed to be within 5% are obtained for the drift velocity in argon.

MDDC - 525 Some Neutron Induced Activities in Rare Earths, by M. G. Inghram and R. J. Hayden. 6p.

Due to difficulties of chemical separation of the rare earths, and to the large number of isotopes of certain of these elements, activities and mass assignments in this range have for some time been in question. The use of a mass spectrograph together with counting equipment made possible the mass assignment of many of these known activities, and led to the discovery of several new active isotopes.

The mass spectrograph used consists of a hot anode source, 60° single focussing magnetic analyzer, and a photographic plate receiver. The dispersion of the instrument is 0.25 cm for a 1% difference in mass.

Activities of all the rare earths are tabulated. The 9.5 hour gadolinium activity reported by Nenesy and Levi was not observed in the purest gadolinium sample, but 4.5 minute, 18 hour, and 8.6 day activities were observed. Analysis of a sample of gadolinium which did show the 8-9.5 hour activity showed it to be due to an impurity of europium giving rise to the 9.2 hour Eu^{152}.

The existence of a second long-lived neutron-induced europium activity has not been previously reported. Mass assignment has shown the 9.2 hour Eu^{152} to be isomeric with one of these long-lived activities. Also a new 102 hour neutron activity was found in ytterbium. Mass assignment of this has show it to be due to 102 hour Yb^{175}.

MDDC - 526 Martempering of K-46 tool and die steel by G. L. Kehl. 12p.

The results of this investigation, limited by the data available, permit the following conclusions to be made;

The M_S temperature of K-46 tool and die steel, having an initial structure of spheroidite and being austenitized at 1475°F, is between 400° and 450°F: Martempering of K-46 steel having an original spheroidized structure may be carried out as follows: Austenitize at 1475°F; quench from 1475°F to a salt or lead alloy bath maintained at 500°F; hold at 500°F for a time dependent upon the size of the piece, but in no case is the holding time to exceed 3 minutes; air cool from 500°F to normal temperature. The maximum size of K-46 steel that can be successfully martempered is a piece equivalent to a cube approximately 1" along a side. Larger equivalent masses can be martempered, but with a significant loss in hardness.

MDDC - 527 Van de Graaf Photographs (Los Alamos) 15p.

Collection of 29 photographs of Van de Graaf machine and circuit diagrams for auxiliary equipment from the Los Alamos Laboratory.

MDDC - 528 A Hollow Cathode Source Applicable to Spectrographic Analysis for the Halogens and Gases, by J. Rand McNally, Jr., George R. Harrison, Eugene Rowe. 19p. (See also Journal of the Optical Society of America Vol. 37 p.93-98, February 1947).

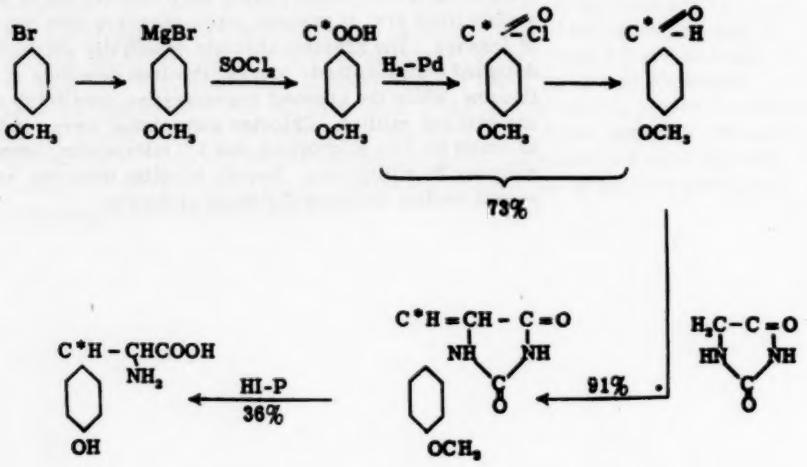
The relative sensitivities of fluorine spectrum lines in the vacuum ultraviolet region and in the visible region were studied, and it was found that certain visible lines are, at present, more sensitive than the theoretical raies ultimes of fluorine. The greatest absolute sensitivity obtained, using a specially designed hollow cathode source, involved detection of about 0.01 microgram of fluorine, while the greatest concentrative sensitivity was slightly less than one part per million. Chlorine and sulphur were readily detected in amounts as small as 0.20 microgram and 1.0 microgram, respectively, in samples weighing 20 milligrams. Sample handling time was reduced sufficiently to permit routine analyses for these elements.

MDDC - 529 Micro-Gas Analysis, by W. A. Nierenberg, Clarke Williams. 12p.

An analytical instrument is described whose purpose is the determination of the composition of a binary gas mixture in a manner similar to the conventional Haldane apparatus, but is capable of handling samples ~0.6 ml. or less. It is consistent and reliable in operation and cheap in manufacture. A single observation is reproducible to ± 0.04% in routine work, and to about ± 0.02% for special analyses.

MDDC - 530 Synthesis of Tyrosine Labeled with C-14, by J. C. Reid. 1p. (See also Science Vol. 105, p. 208, February 21, 1947).

The synthesis of dl-tyrosine labeled with C-14 in the beta position has been carried out. Summary of the synthesis:



MDDC - 531 Forty - Three Day $_{48}Cd^{115}$, by Leo Seren, Don Engelkemeir, William Sturm. 11p. (See also Physical Review Vol. 71, p. 409, April 1, 1947).

A 43 day isotope of cadmium has been discovered while irradiating cadmium with slow neutrons. The radiation consists of β-rays of energy 1.5 Mev, and with approximately one 0.5 Mev γ-ray per disintegration. By means of chemical separations, the radio-element was identified as cadmium, and the mass assignment to $_{48}Cd^{115}$ was made by a fast neutron In^{115} (n,p) Cd^{115} reaction.

MDDC - 532 **Experimental Use of C^{14}; Synthesis of Acetic Acid from Radioactive Carbon Dioxide, by L. B. Spector. 23p.**

Synthesis of acetic acid from radioactive carbon dioxide is based on the following steps: preparation of Grignard reagent; carbonation of the Grignard reagent; distillation of dilute acetic acid; evaporation to sodium acetate; acidification of sodium acetate and distillation; ether extraction and final distillation of acetic acid.

Detailed procedure for the preparation of acetic acid at one-tenth mole level is given.

Experiments on the preparation of acetyl chloride are described in the appendix.

Apparatus setups for carbonation, for liberation of dilute acetic acid solution, for extraction of acetic acid from saturated sodium chloride solution, and for final distillation of concentrated acetic acid solution are diagrammed.

MDDC - 533 **Electronic Circuits - V, by R. J. Watts, et al. 10p.**

Electronic circuits, chassis layouts of model 300 amplitude analyzer, concidence analyzer, pulsers, counter test unit, etc.

MDDC - 534 Changes in Peripheral Blood After Single Doses of External Beta Radiation, by E. Anderson. 12p.

In an effort to discover whether beta ray burns can be correlated with thermal burns, a series of measurements of hematocrit and specific gravity of blood plasma were taken on two rats which had received total body irradiation with 7,500 rep of beta ray. Techniques were selected which gave accurate readings with small samples of blood. The copper sulfate method was used for measuring specific gravity of the plasma.

No significant change in the hematocrit was recorded, but specific gravity readings were below the normal range for rats on the twelfth, fourteenth, and seventeenth days after exposure. These results suggest (1) that the plasma lost due to the beta ray burns is lost at such a low rate that the blood volume remains unchanged but (2) that the lost plasma proteins cannot be replaced quite fast enough to keep their concentration normal. Since death attributed to thermal burns is primarily due to a fall of blood volume, it would appear that the physiological changes taking place are quite different for the two types of burns.

MDDC - 535 A Simple Carbon Dioxide Vapor Pressure Thermometer, by H. C. Anderson. 8p.

A carbon dioxide vapor pressure thermometer is described for use in conjunction with a dry-ice-solvent reference-junction bath. It was necessary to employ a thermometer in order to make certain that equilibrium was prevailing during potentiometric measurements. The apparatus is used as an aid in routine low-temperature measurements over an extended development period.

MDDC - 536 Health Protection in the Production and use of Atomic Energy , by W. F. Bale. 10p. (See also Occupational Medicine Vol 2 p. 1-7, July 1946)

It is pointed out that considerations on the use of controlled atomic energy in peace time would suggest that eventually its employment will be much more widespread and diffused throughout the country rather than concentrated in a few atomic bomb plants as it is at the present time. This means that a great many may be concerned with the maintenance of proper conditions of human safety both in the actual use of atomic energy and during the manufacturing operations leading to its use.

A resume is given of the atomic bomb explosion and comparison with ordinary explosives indicated. Protection from radiation while using atomic power for plane or automobile propulsion is considered Conditions point to use of a fixed site for a power installation. Cost as related to safeguards is discussed. It is seen as a problem involving physicians and other charged with the responsibility of protecting the health of industrial workers.

A discussion is included on nuclear energy as a source of mobile power. Personnel protection from mobile power sources is considered as being feasible in ocean transportation and possibly air travel. The magnitude of world-wide increase in radioactivity as a result of wide spread use of nuclear energy is discussed. The ocean is seen as the most likely safe place for dissipation of excess radiation. The progress made in the study of human tolerance to radioactivity is mentioned and a final work of warning on careless use of radioisotopes in tracer studies is given.

MDDC - 537 Minimum Ionic Kinetic Energy For a Stable Sheath, by D. Pohm. 17p.

The theory of the transition between plasma and sheath is investigated in detail with a simple model, for which the equations can be solved exactly. The general result is that when the mean ionic energy is about half the mean electronic energy, the electrostatic forces resulting from space charge are such as to make the plasma state unstable. and to bring about a rapid transition to a sheath, in which few electrons are present. Actual conditions in the plasma are usually represented to a fair degree of approximation by the simplified model.

MDDC - 538 Atomic Energy and Radiation Chemistry, by M. Burton. 16p.

The theme of the lecture is that there is no secret which can protect the United States from the consequences of its own good fortune, namely the invention of methods for the release of atomic energy. It is stated that the bulk of society must be convinced that there is no protective secret.

The talk is confined to the subjects freely revealed in the published literature and in the Smyth report. A resume of the development of atomic enery, beginning with Einstein's equation, $E = mc^2$ expressed first in 1905 is given, up to and including separation of U^{235} and operation of plutonium pile. It is mentioned that, fortunately, the chemistry of uranium and plutonium is such that chemical separation is feasible by conventional means. It is indicated that chemical routines could be carried out in spite of heavy radiation emanations from the materials involved.

Conclusions reached are, that if another war were imminent, production of plutonium direct would be started without regard to problems of chemical separation from uranium, which might take six months at most to work out. The point is that, other things being equal, a delay of six months at the most would be all that could be expected in view of the information available to any potential enemy. It is reiterated that if a war is not to come before a period of three to five years has elapsed, the little information used for protection, and kept under lock and key, is of very little use for the purpose.

MDDC - 539 Metallurgy in the Development of Atomic Power, by J. Chipman. 38p.

Starting with the inception of the "Metallurgical Laboratory" in 1942, at the University of Chicago, the development of atomic energy is traced, with accent on metallurgical considerations and costs.

Topics are introduced under the following headings and references are made to paragraphs in the Smyth report by number: graphite; the first pile; metallurgy of uranium: production, structure, properties, metallography, alloy diagrams, the coating problem; the metallurgy of plutonium; future developments.

Thorium is also mentioned as fissionable material. Others are considered. Beryllium and its properties are discussed from the standpoint of a moderator.

Predications are made that the difficulties delaying the conversion of atomic energy to peacetime use will eventually be overcome. Use of radioactive tracers in corrosion problems is mentioned and the use of radiography in metallurgical inspection is pointed out. Metallurgical research problems are indicated such as the effects of intense neutron bombardment on a supersaturated solid solution or upon a steel which has been quenched but not tempered. Figures, diagrams and photomicrographs are appended.

MDDC - 540 Uranium Distribution Studies, by Renato J. Ferretti and Samuel Schwartz, 12p., June 15, 1946, decl. 6/15/49. (For publication in NNES)

The microfluorometric method of uranium analysis used in the quantitative determination of as little as 0.0001 μg of uranium has been found to be applicable to the analysis of uranium in rabbit tissues. Studies of fluorescence quenching in these tissues indicate that this is negligible where 0.05 g or less of tissue is used for analysis. Bone and blood produced most fluorescence quenching. Twenty-five milligrams of bone produces roughly 30% quenching of fluorescence in a uranium-sodium fluoride flux. By use of special techniques a correction factor for this quenching may be determined. Highest concentrations of uranium in control rabbits with no known exposure to uranium have been found in the central nervous system. Similar results were obtained in rabbits injected many months earlier with very small doses of uranium. In acute studies, or in chronic studies of rabbits injected with large doses of uranium, highest concentrations are found in bone and kidneys, in confirmation of previous reports. (auth)

MDDC - 541 Uranium Excretion Studies, by R. J. Ferretti, G. R. Price, and S. Schwartz, 18 p., June 15, 1946, decl. 4/9/48. (CH-3592).

Since there are no clinical or biochemical tests known to be specific for uranium toxicity, the determination of uranium in urine is the most important single index for the evaluation of uranium exposure in project personnel. This is illustrated by data of 86 individuals exposed to uranium in the Ames, Chicago, and Oak Ridge projects.

Values of over 100 micrograms U/liter are found only rarely in even the most heavily exposed individuals. Control unexposed students were found to excrete less than 1 microgram U/liter.

Because the fluorimetric method used is sensitive to 0.0001 microgram of uranium, analyses were done using only 0.1 cc urine. This sample is evaporated to dryness in a platinum dish, ashed over a flame, and fused with sodium fluoride without further purification. Fluorescence is then measured with a specially constructed fluorophotometer.

MDDC - 542

Heats of Reaction of the Oxidation-Reduction Couples: H_2O - H_2O_2, Fe^{+2} - Fe^{+3}, Ce^{+3} - Ce^{+4} and U^{+4} - UO_2^{+2}, by B. J. Fontana. 16 p.

The heat of decompostion of H_2O_2 has been determined; the value of ΔH_{298} = -22.59 ± 0.02 kcal./mole being in good agreement with the previous value, -22.64 ± 0.04, cited from the literature.

Determination of the heat of the reaction Mg + HCl (aq), and blank calorimetric experiments indicate that over the temperature intervals ordinarily employed the calorimeter accuracy is satisfactory. A small correction was indicated, however, for the heat of the Fe^{+2} + H_2O_2 reaction previously reported; Δ H (corr.) = -35.89 ± 0.12 kcal/equivalent.

The heat of the U^{+4} - UO_2^{++} couple has been determined, ΔH_{298} = + 32.94 ± 0.06 kcal/mole, through the reaction of U^{+4} + H_2O_2. This heat has been used to redetermine values for the heat of the Fe^{+2} - Fe^{+3} and Ce^{+3} - Ce^{+4} couples; ΔH_{298} = + 9.48 ± 0.08 and +37.83 ± 0.05 kcal/mole, resp., in good agreement with previously reported values.

Application of the U^{+4} - UO_2^{+2} heat to the calculation of the entropy of the U^{+4} ion, using the widely differing E.M.F. data for this couple, appears to indicate that the less negative values, e.g., - 0.328 volts in 0.5 m HCl, are more likely to be correct.

MDDC - 543

Atomic Energy and Cancer, by H. Fridell. 16 p.

Following a general introduction and moving picture of the effects of the Hiroshima bomb, the development of the Manhattan Project and the organization of the Medical Section are mentioned. An industrial medicine division and a clinical medicine division, together with a research division are indicated. The lecture is summarized as follows:

Two fields for development are pointed out:

1. The first is the opportunity for improving the therapeutic approach. New radiations and new radioactive materials in an abundance which were not previously imagined, are now possible. These can be used for external radiation, for interstitial radiation and as radioactive materials in specific compounds which may be localized in various tissues, (phosphorus, strontium, and iodine). A corollary to this is the possible introduction into tumors of elements which are, so to speak, triggered by neutrons to release large amounts of ionizing radiation.

2. A second and perhaps more important approach has been made possible by ability to produce radioactive isotopes in abundance to study the unwarranted behavior of the cancer cell. The key in this probably lies in the use to which we may put C^{14}, but other elements (hydrogen, nitrogen, sulphur, etc.) will be useful.

The success of the Manhattan Project in achieving its goal lies primarily in the fact that its development was based on certain fundamental and substantial corner stones. Although there have not been uncovered such fundamental corner stones in the approach to the cancer solution, real progress can be made by united and intensified efforts.

MDDC - 544 **Tests of Butterfly Valve with Magnetic Transmission, by S. Neal. 23 p.**

Butterfly valve controlled by a magnetic transmission was tested as a flow meter. Data are tabulated which will permit the calculation of the torque due to fluid forces. Those calculations can be made if the density of the fluid and the pressure difference across the valve are known.

It was found that the valve behaved in a stable and satisfactory manner. The magnetic transmission had sufficient torque to control the valve at any point in the test range. The characteristics of the butterfly valve were found similar to other valves of this type.

The report presents not only the test data, but also the test results in a dimensionless form which will facilitate calculation of flow and torque and also will permit application of these data for the use of fluids other than air with geometrically similar valves.

MDDC - 545 **Atomic Bomb Engineering, by A. C. Klein. 36 p.**

A discussion of the contribution made by engineers to the development of the atomic energy electro-magnetic plants.

The atomic bomb program is indicated as being made up of the following principal parts: research and scientific development; design and construction of three major plants utilizing respectively the diffusion process, the electro-magnetic process and the plutonium process; the operation of these plants to produce fission materials; developments including the townsite construction, the development of the raw material program and the construction of heavy water plants.

General discussion and high lights of the construction and operation of the electro-magnetic atomic energy plants is given. A suggested program for Congressional action is summarized.

MDDC - 546 **Engineering Features of the Atomic Plants, by A. C. Klein. 22 p.**

A general and chronological account is given in the lecture of the early days and activities concerned with the building of the electro-magnetic atomic energy plants at Oak Ridge, Tennessee.

Topics include: research and development; procurement of uranium ore and other special raw materials; design and construction of three major plants, one for the production of Plutonium, and two others for the production of U-235 by the diffusion and electromagnetic processes respectively; the production of fissionable materials in these plants; collateral developments including construction of heavy water plants and townsite construction.

Speculation is made on the future of atomic energy plants and power projects.

MDDC - 547 **The Determination of the Ranges of the Fission Fragments Emitting Delayed Neutrons. Chemical Identification of the 4.51s Delayed Neutron Activity, by N. Sugarman. 23 p. (See also Journal of Chemical Physics Vol. 15, p. 544-551, August 1947)**

The ranges of the fission fragments leading to delayed neutron emission have been determined by absorbing the fragments in Al and counting the penetrating activity. The ranges corrected for the source thickness are: 4.51s, 4.05 $\pm$ 0.03 mg Al/cm^2; 55.6s, 3.98 $\pm$ 0.06 mg Al/cm^2; 1.52s, 3.63 $\pm$ 0.12 mg Al/cm^2; 22.0s, 3.21 $\pm$ 0.04 mg Al/cm^2. Comparing the range of the 4.51s period with that of the 55.6s Br period, one finds that mass assignments possible for the 4.51s period are 87 to 90. Similarly, the range of the 1.52s period is compared to that of the 22.0s period, and the possible mass assignments found are 129 to 135.

Chemical separation of Br from irradiated UNH resulted in the identification of the 4.51s activity as an isotope of Br.

MDDC - 548

Report on a Magnetic Drive Design for the Fercleve Corporation by General Engineering and Consulting Laboratory. 48 p.

Designs were required for a permanent magnet drive to couple a motor shaft with a pump impeller through a thick diaphragm of small diameter. The report presents the procedure and results of the magnetic drive development up to date of cancellation of contract and includes the general features of the design which would have been recommended if the contract had not been cancelled. Tests showed that such a drive transmitted a maximum torque to 0.82 foot-pound at the required speed of 40 revolutions per minute (1/160 horsepower) through an airgap 1/2 inch long containing a cylindrical diaphragm of phosphor bronze 3/8 inch thick and 4 inches in diameter.

The following specifications to be met by the desired magnetic drive design were established.

1. Alnico V (G. E. Designation B3C9) to be used to supply the magnetomotive force.
2. Maximum torque 8.8 inch-pounds (0.74 foot-pound)
3. Speed of rotation 40 rpm.
4. To withstand a peak pressure of 4000 pounds per square inch, a cylindrical diaphragm of phosphor bronze with inside diameter of 4 inches and wall thickness 3/8 inch must be used. (Later, when magnetic tests showed it allowable, Eastern Engineering Company increased the required thickness to 1/2 inch).
5. Operating temperature 125 degrees C.
6. The driven rotor inside the diaphragm is to be made of soft steel and is to be heavily nickel plated.

Two working models were built and tested. A list of detail sketch numbers and titles is included.

MDDC - 549

Continuous Purification of Water for Isotopic Analysis by Density Determinations, by Robert L. Burwell, Jr., W. E. Roake, and Malcolm Dole. 4 p.

For the isotopic analysis of water by density determination, an apparatus for the continuous or batch purification of small samples of water was needed. Purified water without significant change of isotopic composition and of a density correct to less than one part per million was desired.

The simplest form of the apparatus developed for this purpose is shown. Water is allowed to flow down a steam jacketed tube up which a current of air is passed. The evaporator tube contains a closely fitting helix of nichrome wire to provide a longer path and better distribution of liquid flow. The rate of admission of water is controlled by the degree of penetration of a nichrome wire into a capillary of but slightly greater diameter. Air or tank nitrogen is purified by passage over heated copper oxide at 600°C. and thence through long towers of soda-lime and calcium chloride. Some results indicate that such purification may be more than necessary but elimination of grease and oil from the air is important. The relative rates of air and water flow are adjusted to keep liquid from the lower third of the evaporator tube. Evaporation takes place without boiling or spray formation. For a tube of 1 cm. internal diameter and 50 cm. long, a suitable rate is 1 cc. of water and 0.4 liters of air per minute.

Water is condensed in the condenser and flows down to the catch basin whence it is diverted to the collector system. It is thus collected and removed from the system while hot (about 90°). Involatile impurities remain in the evaporator. They may be discharged from the bottom of the column by shutting off the air flow for a few minutes daily. Most volatile impurities largely remain in the air stream.

The general performance of the unit is tabulated.

MDDC - 550 **The Construction and Testing of Surface Combustion Furnaces, by L. Brewer, G. H. West. 7 p.**

Two surface combustion furnaces have been constructed and have been used up to 2000°C. Both MgO and ZrO_2 have been found to be satisfactory construction materials. Propane was used for fuel.

MDDC - 551 **The Effect of X-Ray on the in vitro Motility of Feline Intestine by Bradford N. Carver. 4 p. (See also American Journal of Roentgenology and Radium Therapy Vol. 58, p. 357-358, September 1947)**

Five cats were employed in this study. All cats were killed after light anesthesia with sodium pentobarbital by opening the chest. The jejunum and ileum were removed for the experiments, carefully washed out with previously oxygenated ice-cold Locke's solution, divided into six approximately equal and consecutively numbered segments, with exceptions as noted, beginning with the proximal or jejunal end, and then stored in the refrigerator between layers of cotton soaked in oxygenated, cold Locke's solution. The technical irradiational factors in these experiments were: 120 KV; 8 Ma; 7.5'' T.S.D.; 640 r/min. output; H.V.L. = 1.971 mm. Aluminum. No filter was used save that inherent in the instrument.

The exposure in vitro to doses of soft X-ray varying from 1,000 to 10,000 r of strips of small intestine from the cat did not appear to influence significantly their kymographically recorded motility.

The first experiment, although inadequately controlled, would suggest that X-ray exposure of the small intestine two days after its removal from the animal might augment its action, although this putative action was probably illusory. Unfortunately, circumstances did not at the time permit the experments required to settle this point.

MDDC - 552 The Electrolytic Preparation of Fluorine by Ralph C. Downing. 112 p.

The Manhattan District Project of the U. S. Army, Corps. of Engineers required the manufacture of perfluorinated materials on a large scale and consequently the production of unprecedented quantities of fluorine gas.

Early in 1942 a survey was taken under the direction of the OSRD to determine the best and most economical methods for the production of fluorine, as well as to determine the locations at which the manufacture could most advantageously be carried out.

The report gives a history of the events leading to the manufacture of fluorine in large quantities together with details of methods, charts and tabulated data.

An electrolytic cell for the production of fluorine was designed and studies on materials of construction, operating conditions and variations in electrolyte were conducted. Methods of using carbon instead of nickel for the anode were investigated.

Procedures were developed for the analysis of fluorine for hydrogen fluoride, oxygen, fluorine oxide, solids and inert gases and of the electrolyte for acidity, metals and water. Two methods of determining the current efficiency of the cell were used.

Studies on the electrolyte included the distribution of hydrogen fluoride consumption, the separation of a solid phase at low temperatures, the effect of composition and impurities on cell performance and the recovery of used electrolyte and sludge.

Means for the disposal of fluorine, hydrogen fluoride and fluorine oxide were investigated.

A bibliography of 29 references is listed.

MDDC - 553 Delayed Neutrons from Pu^{239} by B. T. Feld, F. deHoffmann. 6 p. (See also Physical Review Vol. 72, p. 567-569, October 1, 1947)

The shape of the decay curve of Pu^{239} delayed neutrons is found to be very closely the same as that of U^{235}. The ratio of the relative number of delayed neutrons in Pu^{239} to that in U^{235} was found to be about 0.47 for delays over 2 seconds and about 0.40 for delays over 5 seconds. In the light of the experimental errors, it is questionable whether these numbers are significantly different.

MDDC - 554 Industrial Health and Medical Rehabilitation at an Atomic Energy Laboratory, by J. S. Felton, M. D. 20 p.

Early in the Manhattan Project development it was deemed mandatory that a health protection plan, of a magnitude unprecedented in established occupational hazard control work, be developed, whereby preventive measures could be taken against the morbid and lethal effects of radiation from an atomic energy pile.

To provide this protection a Health Division was created, and the typical organization was found at the Monsanto Chemical Company, Clinton Laboratories, consisting of three sections; i.e., Medical, Health-Physics, and Biological Research.

The following points are discussed in connection with the program:

The historical development of health protection of the workers at the Clinton Laboratories is presented.

During the transitional period, converting from atomic bomb production to atomic energy research, measures have been instituted to broaden the scope of the industrial health program. The addition of many new workers has made necessary the establishment of such procedures as job analysis, careful selective placement, and studied follow-up of job adjustments.

(Cont'd on next page)

MDDC - 554 **Industrial Health and Medical Rehabilitation at an Atomic Energy Laboratory, by J. S. Felton, M. D. 20 p. (Cont'd from page 333)**

The services available to the employee, and the preventive medicine procedures carried on for each worker are outlined, showing the relation of the worker as, a.) a candidate for employment, b.) as an employee, and c.) as a sick or injured employee.

The classifications used following pre-placement physical examination are discussed and the job and activity restrictions listed, that are an integral part of the physical appraisal and initial job placement.

A medical rehabilitation program has been established, which infers a continued study of the jobs, the employees, their limitations, their absenteeism records, and their relationships with supervison.

The Medical Rehabilitation Section carries on an active liaison with community agencies in order to effect upgrading and improved job relations, in those instances where physical disabilities have made such a change in job status infeasible.

The initiation of this medical rehabilitation program is offered in the form of communications sent to management and to the workers.

A brief outline is given of the types of disabilities presented that have required the attention of the Medical Rehabilitation Section in guidance and referral to community agencies.

A comprehensive reference list is attached.

MDDC -555 The Statistics of the Hypocritical Water Boiler, by S. P. Frankel. 12 p.

A procedure is worked out to show the probability distribution of the number of neutrons at any particular time, P_n (t).

The present problem concerns the probability distribution of the time integral of the number of neutrons present. If a counter is included in the water boiler the probability distribution of the number of counts follows the Poisson law if the time integral of the number of neutrons is definite. In general it will be the average of the Poisson law over the probability distribution of this time integral of the number of neutrons. This distribution is not directly derivable from the above P_n (t) because the distribution in number at two different times are not independent. It is however, derived in a similar manner.

Moments and dispersions are also considered.

MDDC - 556 The Half-life of Be^{10}, by D. J. Hughes, C. Eggler and C. M. Huddleston. 3p.

Because the extremely long half-life of Be^{10} is of interest theoretically, it was decided to attempt its measurement by isolation of the activity produced by the (n,γ) reaction in two BeO samples which had been irradiated for different periods of time in the Hanford pile. Although the BeO was of high purity, it had a gross counting rate of about 5000 counts per min per mg of Be. As the expected Be^{10} activity would be only a few counts per min per mg. it was necessary to purify the samples carefully.

The final samples, which did not decrease in activity with further purification, had an activity of 3.3 counts per min per mg of Be for one sample and 6.7 for another sample that had been irradiated twice as long. Absorption curves of the activities gave an energy of 0.58 ± 0.03 Mev which is in close agreement with the mass difference of Be^{10} and B^{10} (0.58 Mev).

In order to obtain the half-life from the "nvt" and observed activity it is necessary to know the cross section of the (n,γ) reaction.

The cross section for Be^9 (n,γ) was measured by comparing the effect on the reactivity of the Argonne graphite pile of several kilograms of BeO with that of graphite.

The value obtained was 0.01 barns. The half-life of Be^{10} calculated from the activity, "nvt" and the cross section is almost the same for the two samples,

(Cont'd on next page)

MDDC - 556 **The Half-life of Be^{10}, by D. J. Hughes, C. Eggler and C. M. Huddleston. 30 p.** **(Cont'd from page 335).**

the average value being

$$T_{\frac{1}{2}} = 2.9 \times 10^6 \text{ years.}$$

The amount of activity to be expected in the Hanford graphite from the C^{13} (n,α) Be^{10} (fast neutron) reaction was then calculated, using the measured half-life and an (n,α) cross section estimated by comparison with measured pile cross sections for other endothermic reactions. A small sample of graphite which had been in the Hanford pile for about a year was ignited, several mg of Be carrier added, and the Be purification carried out. An activity was obtained of magnitude within a factor of two of that predicted, which did not decay, and had the correct beta energy for Be^{10}. It seems certain then that the activity was Be^{10} produced by the C^{13} (n,α) reaction and the finding constitutes additional support for the correctness of the half-life determination.

MDDC - 557 **Neutron Spectrometer Circuits by Los Alamos Laboratories. 23 p.**

Circuit diagrams.

MDDC - 558 Discriminator for Photographic Analyzer, by M. Sands. 1 p.

This document consists of a one page diagram of a discriminator circuit for photographic analyzer, complete with regulated power supply. (Used with densitometer to check and select films exposed past a preadjusted density value).

MDDC - 559 Delayed Neutrons from Pu^{239}, by R. R. Wilson. 3 p. (See also Physical Review Vol. 71, p. 560 April 15, 1947)

Neutron counts in a BF_3 chamber near a sample of Pu^{239} or U^{235} observed just after having turned off the source of primary neutrons, are attributed to delayed neutrons. It is found that the delayed neutrons from Pu^{239} are distributed in time just as those from U^{235}, as though attributable to the same products, but are about 46% as numerous per fission.

MDDC - 560 Directional Properties of Fission Neutrons, by R. R. Wilson. 14 p. (See also Physical Review Vol. 72 p. 189-192, August 1, 1947).

An experiment has been performed to measure the correlation between directions of neutron and fragment in the fission process. The results are consistent with the isotropic evaporation of neutrons from the moving fragment.

The ratio of the number of neutrons emitted in the forward direction to those emitted at 90^{o} = 0.18 $\pm$ .03. If the average energy of a fission fragment is 70 Mev and the average weight is 100, the energy of evaporation is calculated as $0.7 \times 1.8^{2} \approx 2.2$ Mev .

MDDC - 561 Time for Fission, by R. R. Wilson. 8 p. (See also Physical Review Vol 72, p. 98-100, July 15, 1947).

An experiment has been done to detect if any fissions were delayed by as much as 10^{-8} sec. Less than 5×10^{-5} of the fissions were delayed by this time.

MDDC - 562 The Ryerson Electrometer, by Argonne National Laboratory. 1 p.

The Ryerson electrometer is a modification of the Lindemann electrometer. In both electrometers a fine torsion quartz fiber has a thin fiber attached at right angles to it. These fibers are made electrically conducting and are placed between a pair of metal plates kept at constant potential by a battery. The thin fiber has a fine cross fiber called the viewing fiber, placed on one end for viewing in a microscope. The electrical connection to the fiber system is made by an external binding post insulated by quartz or molded polystyrene. When a potential is applied to this system the needle moves due to the electrostatic field of the charged plates.

In the Ryerson electrometer the needle assembly is made of fused quartz and the instrument is so constructed that the needle or cross fiber cannot touch the plates in any position. The fibers and plates are housed in an airtight aluminum box with windows provided for observing the viewing fiber. A microscope consisting of a 16 mm objective and 25x eyepiece with scale has been found satisfactory for viewing the system. Depending on the particular instrument, plate potentials of from 20 to 30 volts are suitable for giving full scale deflection for 1/10 volt on the needle.

Since there are 100 divisions in the scale this corresponds to a sensitivity of 1000 divisions per volt. Using lower plate potentials one obtains lower sensitivities with correspondingly greater stability and ease of operation. Since the capacity of the electrometer is about $3\mu\mu f$ this instrument is very useful for measuring average currents of the order of 10^{-14} amperes. Weight about 3 ounces.

MDDC - 563

What the Gas Diffusion Process Means to Chemical Engineers, by Manson Benedict. 19 p.

A talk scheduled at the Distillation Symposium of the American Chemical Society, Pittsburg, Pa., Dec. 30, 1946 is presented. Following an introduction in which the unique methods and size of the Oak Ridge plant are subjects of comment, the lecture proceeds under the following topics: brief description of process and plant; principle of process; plant statistics; photographs of plant; difficulties encountered; reasons for success of plant; useful developments from gas diffusion project.

In conclusion an intangible benefit is cited as the improved understanding of other separation processes obtained by comparing them with gas diffusion.

MDDC - 564

Measurements of the Absolute Values of the Cross sections for Ionization of Uranium Tetrachloride and Uranium Hexafluoride by Electrons, by W. E. Berkey, E. H. S. Burhot, J. D. Cragg, J. Keene and H. S. W. Massey, 28 p.

The importance of a knowledge of the absolute values of the cross sections of ionization of uranium tetrachloride and uranium hexafluoride by electrons for the understanding of the performance of arcs run in these vapors is pointed out. The experimental investigation has indicated a value of about 5×10^{-15} cm^2 for the ionization cross section of uranium tetrachloride for electrons of 100 volts energy. From this value an estimate has been made of the expected minimum threshold pressure for operation of an arc in the vapor of this material. The value of the minimum threshold pressure turns out to be about 3.5×10^{-5} mm of Hg. This is appreciably lower than the pressure used in practice, which is about 10^{-3} mm of Hg. The discrepancy of the two values is attributed to the possibility of activation of the filament by uranium metal. A number of measurements of the ionization cross section of uranium hexafluoride were made but the results were unsatisfactory due to difficulties in measuring the vapor pressure.

MDDC - 565 — The Application of Certain Metallic Fluorides to the CoF_3 Process, by W. B. Burford. 16 p.

The practical synthesis of perfluorocarbons using CoF_3 suggested that other metallic fluorides might also be effective fluorinating agents for hydrocarbons. The paper describes a systematic review of likely metallic fluorides which were not prohibitively expensive, with the exception of silver difluoride and antimony pentafluoride, whose characteristics were known as a result of extensive work in other laboratories. All materials tested were prepared with elemental fluorine at elevated temperatures.

The successful application of MnF_3 and CeF_4 as fluorinating agents, in the vapor-phase fluorination of hydrocarbons to perfluorocarbons, is demonstrated on both laboratory and pilot plant scale. In the pilot plant equipment used in these experiments, these materials were found to give better yields with high boiling hydrocarbon feed stocks than CoF_3.

The use of PbF_4, BiF_5, $HgFg$, and the fluorides of chromium is investigated and the experimental difficulties evaluated. Although capable of direct fluorination, it was not felt that they could be successfully applied in the existing apparatus.

It was found that solid metallic fluorides of metals having high oxidation potentials, lying above Fe^{+3} in a table of potentials, all gave rise to substitution when reacted with hydrocarbon, but that similar fluorides of elements lying below this were not in general successful in accomplishing the substitution.

MDDC - 566 The Mechanism Disproportionation of Pu(V), by R. E. Connick, 23 p.

The disproportionation of Pu (V) into Pu (VI) and Pu (IV) or Pu(III) is expected to proceed by either of two possible mechanisms. From a study of the rate of the disproportionation in 0.5 M hydrochloric acid, it is shown that the actual mechanism consists of the slow reaction

$$Pu(V) + Pu(III) \longrightarrow 2Pu(IV)$$

coupled with the rapid equilibrium

$$Pu(V) + Pu(IV) \leq Pu(III) + Pu(VI).$$

A possible explanation of the faster reaction through this mechanism compared to that of the other possible mechanism is given.

The mechanism of disproportionation of Pu(V) is essentially the reverse of that for the disproportionation of Pu(IV). The rate constant for this latter reaction is calculated and compared with experimental data.

The importance of the mechanism of disproportionation of Pu(V) in the reduction of Pu(VI) is discussed.

MDDC - 567 Production of High Boron Steel, by R. M. Fowler. 2p.

It was thought desirable to make a series of experimental heats to see what percentage of boron could be added to a steel without rendering it unforgeable. A total of 21 heats was made in a small laboratory induction furnace. These varied from 6-pound to 80-pound heats. The raw materials were ingot iron, ferroboron, ferrosilicon, and ferromanganese. The steels were melted in a magnesia-lined crucible and cast into small ingots. Steels ranging from 0.44% boron to 3.34% boron were made and cast successfully. They were made to contain 0.75% manganese and 0.25% silicon. The recovery of ferroboron was satisfactory; for example, 1.67% boron was added to one heat as ferroboron and 1.54% was recovered. The ferroboron used contained 17.74% boron. The ingots were reheated to 1000°C. and forged to 1-in. square bars. The steel containing 3.34% boron was forged to 1-in bars and flattened to 1/2-in. strip, but when the strip was reheated to 1000°C. and an attempt made to roll it, the material broke up on rolling. The 1.5% boron steels were heated to 1000°C. and rolled to 1/4-in. strip without difficulty.

MDDC - 568 Supplementary Table of Copper Spark Sensitivities by Mark Fred and Frank S. Tompkins, 1 p.

Element	Grating Order	Wavelength (A)	Sensitivity (m)
Np	2	4164.5	200
Pu	2	3709.1	200

This is an extension of the table of sensitivities which appears as Table I in the "collected paper" on spectrochemical analysis by the copper spark method, Book I Division VIII of the National Nuclear Energy Series (MPTS). See MDDC-345.

MDDC - 569 Correlation of Tissue Responses Following Exposure to Penetrating Radiations, by P. S. Henshaw and R. S. Snider. 19 p.

A review has been made of the available information concerning tumor formation and the accompanying changes in mammalian forms that take place following exposures to penetrating radiations.

The tissues in the order of increasing resistance to radiation may be listed as follows: lymph nodes (small lymphocytes), germinal epithelium of the testis, erythrocytes and myeloblasts, gastrointestinal epithelium, ovary, skin, connective tissue, bone, liver, pancreas, kidney, nerve, brain, and muscle.

It was pointed out that the most radiosensitive tissues are of the generative type - that is, those which in life are continually proliferating new cells which undergo maturation, serve a useful function for a limited period and then die.

The skin, testis, hemopoietic organs, gastro-intestinal epithelium and perhaps other tissue series show a parallel type of differentiation with these features in common.

In all cases, certain parent cells (but not the most primative types), were found to be the most susceptible to radiation.

It is plain that partial damage to a particular tissue series results in a limited period during which mature cells are being formed, whereas complete damage results in sterilization.

Stress was laid on the fact that recovery to an apparantly normal condition takes place even when the acute histologic destruction has been almost complete.

MDDC - 570

Review of Information Bearing on the Tumor Inducing Action of Superficial Radiations, by P. S. Henshaw and R. S. Snider. 16 p.

The pertinent facts associated at this time with induction of skin tumors with superficial radiations may be indicated as follows:

It is important to remember that skin consists of layers of cells with the germinal layer at the base, and that the germinal layer proliferated other germinal cells and cells which become differentiated first to form an intermediate layer and finally the dead corneal layer.

In the skin there must continually be a residuum of active germinal cells and a process of maturation to death of cells in order to have normal skin function.

Skin abnormalities consist of three types: (1) failures manifested as drying, scaling, fissuring, lessened resiliency, and reduced regenerative capacity; (2) anomalies such as badly formed nails, poor quality of hair, and poorly developed teeth; and (3) excesses involving overgrowth and overfunction as in neoplasia.

Radiation absorbed in the skin causes damage primarily in the germinal layer. When the damage to this layer is partial, the effect is a skin failure; the germinal layer is unable to proliferate enough cells to maintain the integument with the result that there is drying, scaling, fissuring, possible loss of hair, etc. Repair takes place from the floor of the damaged area, however, from living germinal cells that remain. When damage to the germinal layer is complete the effect is skin sterilization; not only is there drying and scaling, but also there is exudation, sloughing and ulcer formation. In this case healing must be from the edges as no germinal elements remain.

Skin tumors often arise out of such wounds that have become refractory.

In the case of superficial radiations skin tumors (of practically every type) have been observed to appear in animals that display little or no gross evidence of skin break down.

Single applications of beta rays have been observed to be carcinogenic, as many as 50 to 100 loci of tumor growth being produced on rats that ordinarily show no skin lesions.

MDDC - 571

Plant Studies (The Fixation and Absorption of Fission Products by Plants), by L. Jacobson and R. Overstreet. 7 p.

Preliminary experiments indicate that most of the fission products may be firmly fixed on soil. The purpose of the work reported has been to determine whether or not radio-elements so fixed are available to plants.

The test plants selected were three-week old barley plants. This plant was chosen because its method of culture has been well standardized. Plants so grown acquire the ability of absorbing inorganic nutrients quite readily.

These plants were exposed to radio-elements in two different ways. First the plants were immersed for 24 hours in suspensions of purified Wyoming bentonite to which had been added the desired radio-element. Second, the plants were placed in nutrient solutions for a period of three weeks. The radio-element was added directly to the solution. It was not considered advisable to conduct the clay experiments for longer periods than 24 hours owing to the absence of the necessary nutrients. Had nutrient salts been added the clay would have flocculated and settled away from the root zone.

Of the elements investigated, Sr is by far the most readily absorbed and translocated. The other elements fall in the following order: Y, Ce, Zr and Cb. A comparison of the results of the 24-hour period of the clay experiments with those of the three-week period of the culture solution experiments indicates that with the exception of Sr, the radio-elements when adsorbed on suspended clay particles, are more readily accessible for absorption and translocation by the plant. The character of the culture solution is such the Y, Ce, and Zr, and Cb are probably precipitated within a short time on the roots, walls, etc. in a form non-available for absorption by plants. Sr, on the other hand, remains largely in solution as would be expected and is readily available for absorption.

In order to obtain information supplementary to that given by the plant experiments, an examination was made of active algae collected from the settling basin at Clinton. Judging from the assay of the algae collected, it would appear that the same phenomena observed with roots are operated here.

MDDC - 572 Nitrogen, (Analytical Chemistry of the Manhattan Project), by K. J. Jensen and R. J. Mundy. 15 p.

The chief need for the determination of nitrogen was in connection with the quality of uranium metal. In one connection or another, occasion arose for the determination in its various states of oxidation in compounds and mixtures. Semimicro and micro modifications of the Kjeldahl procedure were utilized extensively; the final measurement was made either by titration or colorimetrically with Nessler's reagent. In many instances the free nitric acid content of uranium and thorium nitrate solutions was required.

The micro Kjeldahl method is most commonly used for the determination of nitrogen in uranium samples. The method was also applied successfully to thorium samples. The results obtained are consistent and there has been fair correlation with results from the vacuum fusion method.

Information is detailed under the following topics: methods of solution; methods of determination of nitride nitrogen; volumetric micro-Kjeldahl method for uranium and thorium metal; colorimetric micro-Kjeldahl method; volumes of permanent standard solutions necessary to match colors of ammonium chloride standards; macro Kjeldahl method for uranium metal; method of determination of nitrate nitrogen; macro reduction method; indigo carmen; methods of determination of nitric acid and nitrate; peroxide precipitation method; ferrocyanide precipitation method; procedure for ether solution; procedure for water solutions.

A list of 34 references is included.

MDDC - 573 The Measurement of the Surface Tension of UF_6 at Two Temperatures, by H. F. Priest. 4 p.

One of the physical properties of liquid uranium hexafluoride which is of importance in designing equipment for use with the material is the surface tension. If the surface tension is quite normal no further consideration need be given the property, but if it should turn out to be abnormal, special consideration must be given to that fact in designing apparatus for handling the liquid. The purpose of the work described was to determine the degree of normality of the surface tension of liquid uranium hexafluoride. For that reason, in the interest of saving time, the measurement was made with no attempt at great precision.

For the measurement of surface tension of liquid UF_6, one is immediately confronted with the problem of working in a closed system because of the fact that liquid UF_6 exists only under pressure in excess of 25 pounds/ p.s.i.a., and also because of the extreme reactivity of the material with moist air. The capillary rise method was chosen as the simplest method for use with a closed system, the surface tension being calculated according to the following equation:

Surface tension = $\frac{1}{2}$ hdgr.
h = height of capillary rise in cm.
d = density of liquid
g = acceleration of gravity 980 cm/sec^2
r = radius of capillary in cm.

Apparatus and experimental procedure is detailed. Results are tabulated.

Comparison of the surface tension of UF_6 with that of such liquids as chloroform and benzene shows a value very similar to that for these liquids indicating that one can expect UF_6 to act like a normal organic liquid in so far as surface tension is concerned. Furthermore the temperature coefficient indicates that the surface tension temperature curve falls in the same family as the similar curve for benzene and chloroform.

The surface tension of UF_6 has been measured to $\pm$ 3% at 65°C. and 72.5°C. giving values of 17.66 dyne/cm. at 65°C. and 16.48 dyne/cm. at 72.5°C.

The surface tension is normal for an unassociated non-polar liquid and has a temperature coefficient similar to that for such liquids.

MDDC - 574 The Preparation of Tungsten Hexafluoride, by H. F. Priest and R. Colton. 3 p.

Because of the possibility that tungsten hexafluoride might occur as an impurity in uranium hexafluoride it seemed worthwhile to prepare some of the material in order to become familiar with its mode of preparation, reactions, etc.

A sample of 100 mesh tungsten powder was obtained, and because of the volatility of the fluoride (b.p. 19° C.) it seemed likely that direct combination with fluorine would be the simplest mode of preparation.

A one hundred gram sample of tungsten metal was weighed into a nickel boat and placed in a nickel reactor 2" diameter and 14" long. The reactor was fitted with heaters and controls for maintaining the temperature at any desired level.

The outlet of the furnace was connected to a nickel trap immersed in dry ice-trichlorethylene slush, and thence to the vent stack. Fluorine was provided from a pot type, high temperature fluorine cell. The experimental set up is shown schematically.

A striking difference between UF_6 and WF_6 was noted in that only slight fuming of the WF_6 was noticed on exposure to moist air whereas UF_6 fumes copiously.

Solubility experiments were run to ascertain solubility of UO_3, UF_4, UO_2, UO_2F_2, and NaF in WF_6. While the tests were rough and little more than qualitative, it appeared, as a result of the experiments that the solubility of each of these components is so small as to be undetectable by the method used.

MDDC - 575 **The Production of Fluorocarbons by the Reaction of Fluorine with Silicon Carbide, by H. F. Priest and A. V. Grosse. 4 p.**

It has been suggested that fluorine and silicon carbide would react smoothly to produce silicon tetrafluoride and carbon tetrafluoride.

Because of the nature of the reaction it was felt that some fluorocarbons of molecular weight higher than that of CF_4 might be produced.

A Dennis type fluorine cell operating at 40 amperes was available as a source of fluorine.

The reactor consisted of a 1" OD copper tube fitted with screw caps designed to be used either with a copper plug or with aluminum phosphate sight glasses. The reactor was 16" long, the central 14" portion of which was heated in a tube furnace. A copper boat was used to hold the reactants. The reactor with a charge of material is shown in cross section, and the complete apparatus is diagrammed.

In order to make a run the reactor was charged with 30 mesh silicon carbide and heated to 100°C. A piece of silicon was introduced at the front end of the charge as an igniter. Fluorine was then turned on and ignited the silicon which in turn ignited the silicon carbide. The reaction products passed through three cold finger traps cooled with water ice, dry ice, and liquid oxygen respectively.

At the completion of a run the traps were allowed to warm up, and the gas evolved was bubbled through sodium hydroxide solution to remove the silicon tetrafluoride, the residual gas finally being stored over water in glass carboys. When enough gas accumulated to make 500 ml. of liquid it was condensed and fractionated on a low pressure, vacuum jacketed, packed,distillation column.

By combining the product of the distillation with the non volatile material left in the traps after warming to room temperature, 100 grams of 30 mesh silicon carbide gave approximately 5 ml. of fluorocarbon boiling above room temperature.

Because of the large volume of gas that had to be handled for a small amount of product, the method was abandoned. However, the method is very useful as a smooth method for preparing CF_4 and is reported as such.

MDDC - 576 A Simple Laboratory Electrolysis Cell for the Production of Fluorine, by H. F. Priest. 3 p.

In producing fluorine for use in an experimental laboratory, one is confronted with several problems not usually present when fluorine is used in a process operation. One of these, and the most important problem is the fact that the cell is used only occasionally, and in the ordinary pot cell the electrolyte picks up water which produces oxygen when electrolysis is resumed.

The Dennis type cell obviates some of the difficulty due to water vapor, but is inconvenient to build, is rather bulky, and has a weld which frequently develops leaks.

In the cell shown the electrolyte is protected form absorbing atmospheric moisture by being covered, and the cell has several additional advantages. The cell, except for the covers and flanges, is fabricated from sweat type copper tube fittings using phoscopper hard solder. The chambers on each side, because of their construction, have large sludge collection volumes so that sludge trouble is minimized.

Electrode graphite carbon rods 1" in diameter are used as electrodes. HF for make up is added through the tube provided on the cathode side of the cell. The hydrogen goes off through the 1/2" copper tubing provided. The fluorine is led off through a 1/4" copper tube in the anode compartment through a sodium fluoride trap.

The electrodes are clamped in place by the flanged nut clamping on the "Teflon" gasket. The electrode is fastened to the gasket by means of the special clamp which is threaded on the underside to receive the electrode and fitted with a terminal on the top side for electrical connection.

MDDC - 577 Thermocouple Elements of the Concentric Type for Use in Small Wells, by H. F. Priest. 1 p.

In order to make a thermocouple small enough to go into a hole 0.030 inches in diameter ordinarily it is necessary to use very small wires for the element which results in very high resistances for the circuits. In some work with thermal flowmeters a different type of thermocouple with low resistance would be desirable.

A satisfactory element was made up as follows. Six foot lengths of glass fiber and shellac insulated constantan wire with an O.D of 0.014" on the wire and 0.018" for the insulated wire was sheathed with an annealed copper sheath 0.05" thick giving a total diameter of 0.028". This material was used as the thermocouple elements. The junctions were made by soft or silver soldering the constantan to the sheath. By filing a section of the sheath away in the center of the element and soldering copper leads to the two halves a complete thermocouple element was made. It was usually desirable to anneal the elements at 100° C. above the operating temperature for 48 hours before using.

The outside of the unit was covered with Bakelite varnish to insulate it from the well.

Another added feature of this type of thermocouple is that it can be easily forced into deep wells even if the wells are not straight because the concentric construction produces a relatively stiff product.

This type of thermocouple would not be recommended for highly precise temperature measurement, but for measurement to the nearest 0.02° C. it has proved to be extremely convenient, rugged and dependable.

MDDC - 578 **Delayed Effects of Single Exposures to Beta Rays, by J. R. Raper, P. S. Henshaw, R. S. Snider. 17 p.**

The delayed effects of single exposure to beta rays differ only in detail from the late effects of high doses of penetrating radiations such as X-rays and gamma rays. The later effects include alopecia, telangiectasis, atrophy, keratosis, ulceration, and tumor induction.

Of the species of laboratory animals studied, mice, rats, guinea pigs, and rabbits, only rats showed any apparent specific effect of beta irradiation. The induction of tumors, of several types but chiefly epidermal in origin, was evident as early as 4-5 months after exposure to 4000 and 5000 rep. At the end of a year each animal exposed to either of these doses was affected by a multiplicity of neoplastic growths (an average of 12.6 tumors per individual in the group exposed to 4000 rep).

MDDC - 579 **The Effects of External Irradiation with Beta Rays on the Peripheral Blood of Rabbits, by J. R. Raper, K. K. Barnes. 8 p.**

Blood studies on rabbits which received total surface irradiation with beta rays, in doses ranging from 1500 rep to 59,000 rep, revealed no direct effect on the cellular constituents of peripheral blood. Sporadic increases of heterophils beginning three weeks after irradiation with intermediate doses, 10,000 rep, coincided with infection of ulcerated skin.

No evidence of indirect effects on white blood cells was found nor was there any evidence to substantiate a claim of lymphocyte stimulation by superficial irradiation.

The lack of effect is considered consistent with the physical properties of the radiation and the anatomical features of the rabbit.

MDDC - 580 **Effects of Periodic Total Surface Beta Irradiation, by J. R. Raper, P. S. Henshaw, R. S. Snider. 21 p.**

Daily total surface irradiation with 625 rep of beta rays produced in mice and rats damage comparable to that previously described as the result of single exposure to beta rays at dosage levels slightly greater than the respective median lethal doses. Under prolonged irradiation the time scale for the response was considerably expanded as compared to that of single exposure; 50% mortality occurred in mice 89 days, and in rats 90 days, after the initiation of treatment, at which times total doses of 43,750 and 46, 250 rep had been administered to mice and rats respectively.

A significant increase in the incidence of subcutaneous tumors resulted in rats from daily irradiation with 50 rep/day during a period of a year. At the end of nine months of irradiation with 50 rep/day, mice showed slight epilation and occasional ulceration and there was some evidence of precancerous activity.

Lower daily doses of beta rays, 5.0 and 0.5 rep/day to rats and 5.0 rep/day to mice, have to date produced no discernible effects.

MDDC - 581 **Analytical Chemistry of the Manhattan Project, Chap. XXI Carbon, Hydrogen and Oxygen, by C. J. Rodden. 27 p.**

Following a resume of methods, detailed procedures are given under the following headings: carbon and hydrogen, simultaneous determination of carbon and hydrogen, apparatus, blank corrections, procedure; determinations of carbon in uranium and uranium compounds, procedure; water, determination of water in uranium trioxide, apparatus, procedure; determination of water in UF_4, copper tube method, apparatus, procedure; sodium carbonate method, procedure; determination of water in uranyl sulfate, apparatus, procedure; determination of water in ethereal solutions, procedure; oxygen, determination of combined oxygen in thorium metal, procedure.

A list of 28 references is included.

MDDC - 582 This document is temporarily unavailable.

MDDC - 583 Histopathological Studies on Mice Following External Beta Ray Treatment, by Ray S. Snider. 17 p.

Experiments were undertaken to investigate the reactions of animals treated with external β rays. In addition, the effects of external β rays, which reach little beyond the skin (the half-thickness or half-layer value in tissue is 0.76 mm), are compared (1) with the effects of X-rays, which pass through the animal, and (2) with the extensively reported effects of ultra-violet rays, which like external β rays, do not penetrate into the deeper organs.

Histopathological studies are reported on CF1 male mice following single external β ray treatments of 5000r and 2500r.

Damage was restricted to those superficial tissues which were generally susceptible to damage by irradiation: the epidermis, derma, parts of the spleen and testis, and the marrow in the bones of the skull, feet and sternum.

Damage was more severe after the larger dose, but no alterations were characteristic of one dose and not of the other.

Damage to the epidermis, in the form of clumped chromatin of certain cells in the basal layer, was found almost immediately after irradiation. Degenerative signs become more conspicuous through the 8-and 24-hour intervals, when the nuclei became swollen and vacuolated. At 15 to 21 days the basal layer broke down completely in many regions of the body, and some of the skin

(Cont'd on next page)

MDDC - 583 Histopathological Studies on Mice Following External Beta Ray Treatment, by Ray S. Snider. 17 p. (Cont'd from page 354).

ulcers which followed soon thereafter were not fully healed at 3 months.

In the animals surviving the treatment for the greatest length of time (3 months) the epidermis contained thickened areas and "downgrowths" which have been considered by many previous authors to be an early indication of a developing malignant process.

The derma also underwent alterations almost immediately after treatment. The formation of edema, breakdown of mast cells, invasion of the connective tissue by heterophil leucocytes, swelling of the collagen, and the occlusion of blood and lymph vessels became progressively more severe during the first 6 to 10 days after treatment and then gradually subsided, although in some regions the derma still appeared to be abnormal 3 months after irradiation.

In general, the tissues reached by external β rays were altered in much the same way as were similar tissues treated by comparable doses of X-rays.

MDDC - 584 Comparative Effectiveness and Additivity of Fission Neutrons, Gamma Rays, and Beta Rays on Drosophila Eggs, by G. E. Stapleton, R. E. Zirkle. 32 p.

Some investigations have been made to ascertain the similarity of the mechanism of action of radiations which are different in their specific ionization. A suggested approach was to determine if the energies absorbed from the different types of radiation are additive in their lethal effects on biological objects.

In an attempt to determine the additivity of ionizing radiations various dose combinations of fast neutrons, gamma rays and beta rays were administered to Drosophila eggs. These test objects were chosen because their dimensions are such that they tend to absorb these three radiations uniformly throughout their volume.

Although the three radiations were found to vary in their biological effectiveness, per unit energy absorbed, all three were shown to be completely additive in their lethal effect on these organisms.

MDDC - 585

Components of the Acute Lethal Actions of Slow Neutrons, by R. E. Zirkle. 6 p. (See also Radiology Vol. 49 p. 271-273, September 1947)

Various groups of mice were exposed to graded doses of slow neutrons as determined by measuring the radioactivity induced in suitable metal foils. The number of mice surviving for three weeks was plotted against dose, and the resulting curve showed that the 50 per cent survival dose was 4.2×10^{12} slow neutrons per square centimeter of mouse.

This dose of slow neutrons, under the conditions of the experiment, was associated with the following measurable and calculable partial doses due to ionizing agents of various origin.

Fast neutrons. Under the conditions of the experiment, the slow neutrons were badly contaminated with fast neutrons. These were measured directly in n-units in the usual way. (The n is the amount of fast neutron radiation which produces one scale reading of a Victoreen r-meter equipped with a standard 100 r chamber.) The dose of fast neutrons which accompanied 4.2×10^{12} slow neutrons per cm^2 was 45 n.

Gamma rays, almost entirely originating in capture reactions. The chief of these reactions was capture of neutrons by hydrogen nuclei to form deuterium nuclei plus gamma rays. The dose of gamma rays associated with 4.2×10^{12} neutrons per cm^2 was calculated to be 84r.

Protons and carbon nuclei produced by the transmutation of body nitrogen. Nitrogen-14 plus a neutron yields a fast proton and a fast nucleus of carbon-14.

Radioactivity is induced through neutron capture by certain body elements, and a fair fraction of the radioactive substances so formed stay in the body long enough to irradiate it.

Other mechanisms leading to production of ionization tracks in the mice were also known, but these could be shown to be quite small in comparison to the four just described.

The various contributions to the total 50% survival dose may be shown in terms of the biological effectiveness of the n-unit of fast neutrons: (1) the fast neutron contamination of the slow neutrons, 45 n; (2) capture gamma rays, 9 n; (3) the reaction $N^{14}(n,p)C^{14}$, 36 to 45 n (In later published results this was given as 54 to 68 n); radioactivity 1 n. The total lies between 91 and 100 n. (In later published results total = 109 and 123 n).

This result is to be compared with the 50% survival dose of fast neutrons alone for the same strain of mice, which in an earlier experiment, was found to be 91 n.

MDDC - 586 **Formation of Focussed Space-Charge Limited Electron and Ion Beams. Part II. Design of Electrodes, by O. Buneman, E. U. Condon and A. Latter. 22p. Part I see MDDC-517.**

Contents: potential distribution within the beam, off the axis, and on the beam boundary; methods for solving Laplace's equation in the region outside the beam; theory of series development of the potential in the Laplace region; equipotential patterns for hyperbolic beam shapes; importance of space-charge; estimate of accuracy of series approximations; analytic solution of potential problem; effect of variation of beam shape parameters; sensitivity of beam shape to variation of axial potential; composite ion beams; selection of suitable electrodes and modifications of ideal shapes for practical purposes.

MDDC - 587 **The Determination of the Oxidation Number of Pu (VI), by R. E. Connick, J. W. Gofman, J. W. McVey, G. E. Sheline. 14 p.**

The determination of the change in oxidation number of Pu(VI) when oxidized by dichromate is described. It was found that two equivalents of dichromate are consumed per mole of plutonium oxidized when the reaction occurs in the presence of an excess of either dichromate or plutonium. Therefore it is concluded that the oxidized state of plutonium is Pu(VI) and that the +5 state is not produced by dichromate oxidation.

MDDC - 588 Vacuum Properties of Plastic Materials, by L. Cook. 33 p.

A number of plastic materials have been examined to provide design information for the construction of the Synchrotron vacuum chamber. The rate of evolution of gas was measured as a function of temperature while heating the materials in vacuum. The resulting data are given in graphical form and formulae are given for the application of the results to vacuum chamber design. The results are in no way intended to represent the yapor pressures of the materials studied and it is pointed out that indeed such samples do not have such a property.

MDDC - 589 The Specific Heats at High Temperatures of Uranium, Uranium Trichloride and Uranium Tetrachloride, by D. C. Ginnings and R. J. Corruccini. 23 p.

The method consisted of heating the sample in a furnace to a known temperature and dropping it into an ice calorimeter which measured the heat evolved in cooling the sample to 0°C. The calorimeter was calibrated electrically. The sample was sealed in a Nichrome-V capsule having a screw cap and gold gasket. The heat capacity of the empty capsule and the heat lost by the container during the drop were accounted for by "blank" experiments made with the empty capsule. The temperature of the sample was measured by a platinum platinum-rhodium thermocouple which had been calibrated at the National Bureau of Standards.

The enthalpies refer to 0°C of uranium in the range 0 to 900°C, of uranium trichloride in the range 0 to 725°C, and of uranium tetrachloride in the range 0 to 425°C.

The two first-order transformations of uranium were observed and the heats of transition calculated from the experimental data. No evidence of first or second-order transitions in the chlorides was found.

Results are tabulated and discussed.

MDDC - 590 **Thermodynamic Properties of Air at High Temperatures, by J. O. Hirschfelder, J. L. Magee. 38 p.**

Knowledge of the thermodynamical properties of air is surprisingly incomplete. In the lower temperature range, i.e. below 25,000°K, Brinkley, Kirkwood, and Richardson (BKR) (OSRD-3550) and Bethe (OSRD-369) have not computed enough primary points to permit accurate determinations of the variation of the thermodynamical properties along adiabats. The secondary tables which BKR have computed are extremely rough and cannot be used satisfactorily for following the shock hydrodynamics by the method of characteristics. Similarly in the high temperature range, Fuchs, Kynch, and Peierls (FKP) (MS-81; BM-83) have not computed enough primary points and they do not consider extremely low densities. The present authors have tried to fill in additional points by making crude assumptions which make the calculations quick but inaccurate. They then attempted to fit these computations smoothly onto the published results. The following tables are therefore unsatisfactory, but they are qualitatively correct and should serve to obtain the qualitative and semi-quantitative features of the hydrodynamics of shocks in air. It seems highly desirable that accurate tables of the thermodynamical properties of air be computed. This project would be easy to set up but the actual computations are sufficiently difficult that it would require approximately ten people for one year.

The thermodynamical tables are set up in two sections. The first gives essentially the primary points with only a slight amount of smoothing. Because the value of gamma jumps with temperature and pressure in a very erratic fashion, these first tables are not suitable for hydrodynamical shock calculations with either the method of characteristics or the I.B.M. machine. In the second section, the equation of state has been put into a form suitable for I.B.M. and characteristic calculations. This has involved a considerable amount of smoothing and some loss of accuracy.

MDDC - 591 **Absorption Spectra of Plutonium in Aqueous Solution. Fine Structure and Analytical Applications, by M. Kasha. 12 p.**

The absorption spectra of uncomplexed Pu(III), Pu(IV), Pu(V), and Pu(VI) and the spectrum of colloidal Pu(IV) are plotted together on a common wavelength scale, permitting comparisons of positions, widths, and intensities of bands. The colors of plutonium ions in various acids are summarized. Spectrophotometric data for uncomplexed Pu(III), Pu(IV), Pu(V), and Pu(VI) are tabulated, and the method of calculation outlined. The physical basis for the sharpness of the absorption spectra of the rare earths, uranium, neptunium, and plutonium is discussed. The fine structure of a region of the absorption curves of uranyl and plutonyl are interpreted in terms of a metal-oxygen vibration.

MDDC - 592 **Atomic Energy in Industry by I. Perlman. 16 p. Nov. 18, 1946. (See also Journal of Chemical Education Vol. 24, p. 115-120 March 1947).**

General discussion of atomic energy and its possibilities is presented. Topics include: the nuclear chain reaction; piles; energy release and plutonium production; technological problems; atomic industry of the future; the power industry; probable mobile power units in ocean going vessels.

MDDC - 593 Model 50 Power Supply (Dwg. #390) (LADC-98), by M. Sands. 1 p.

This document consists of a one page circuit diagram giving a circuit for supplying: (1) 6.3 volts A. C. at 5.5 amperes, (2) 300 volts @ 200 ma. D.C. - regulated, and (3) approximately 150 volts D. C. under proper load conditions. Two transformers and six electronic tubes are incorporated. A VR 105 is used as a voltage reference and both series and shunt regulation is incorporated. 0.1% Ch. output - 1% Ch. input voltage.

MDDC - 594 Model 260 Sweep, by M. Sands. 1 p.

This consists of a one page circuit diagram giving a circuit for operating an oscilloscope tube such that the sweep can be sychronized with an incoming random pulse. The circuit provides for: (1) A sweep speed variable from 0.1 to 10,000 micro seconds per inch, (2) auxilliary focus of beam, (3) centering of beam, and (4) length of sweep. In addition a power supply for the sweep circuit, and an amplifier for the vertical pulse is included. The entire circuit consists of thirteen tubes plus six power supply tubes. Sensitive to either positive or negative pulse.

MDDC - 595

Treatment of Plutonium Poisoning by Metal Displacement by J. Schubert. 8 p. December 1946 (See also Science Vol 105, p. 389-390 April 11, 1947)

From a consideration of ion exchange principles it was predicted that the excretion of plutonium from "plutonized" animals would be increased by treatment with large amounts of the soluble salts of certain metals such as zirconium.

The injection solution used contained from 20 to 25 milligrams of Zr dissolved in ten per cent sodium citrate.

Young adult (200 gm.) albino female rats and a young mongrel dog were used. Following the intravenous injection of plutonium, the time zirconium treatment was begun varied from a period as short as two hours to one as long as five months in the case of the dog. The rats received intraperitoneal and the dog intravenous injections of the zirconium citrate solution.

The effect of zirconium treatment on the urinary excretion of plutonium is tabulated. The administration of zirconium in those rats treated shortly after the injection of plutonium was followed by as much as a fifteen-old increase in the amount of plutonium excreted in the urine over a 24 hour period. When the output of Pu had dropped, a re-injection of zirconium was followed by a second rise in the elimination rate. Actually, the re-injected rats excreted nearly as much plutonium on the fourth day following plutonium administration as the control rats eliminated during the first twenty four hours. Finally, the sustained therapeutic action was shown by the observation that the Pu excretion level remained about three times greater than that of the controls for several days after the cessation of zirconium therapy.

A small part of the heightened excretion of Pu was due to the sodium citrate solvent.

From a study of the toxicity of zirconium and other metals, it was concluded that Zr was by far the safest metal to be used therapeutically.

MDDC - 596 **Analytical Chemistry of the Manhattan Project Chapter XXXI - Iron, Cobalt, and Nickel, by R. W. Bane and W. R. Grimes. 34 p.**

Analytical separation methods are discussed. Headings include: Iron: methods of solution; methods of separation, precipitation (alkaline peroxide), carbonate separation, pyridine separation, cupferron separation; solvent extraction, extraction of ferric chloride, extraction of iron 8-hydroxyquinolate (oxinate), extraction of iron cupferrate; separation of iron from uranium; procedure (cupferron extraction); electrolysis; determination of iron; survey of various colorimetric methods for determination of iron; gravimetric methods; volumetric methods; iodometric methods; colorimetric methods; 1,10-phenanthroline; interferences in the determination of iron with 1,10-phenanthroline; dimethylglyoxime; interferences in the determination of iron with dimethylglyoxime; disodium-1,2-dihydroxybenzene-3, 5-disulfonate (tiron); interferences in the determination of iron with disodium-1,2-dihydroxybenzene-3,5-disulfonate (tiron); 8-hydroxyquinoline; salicylic acid; Cobalt: methods of solution; methods of separation; methods of determination; optimum range for determination of traces of cobalt; colorimetric methods; sodium diethyldithiocarbamate; polarographic method; Nickel: methods of separation; methods of determination; optimum range of methods for determination traces of nickel; colorimetric methods; (bromine as oxidant); (ammonium persulfate as oxidant); polorographic method.

A list of 73 references is appended.

MDDC - 597 **Qualitative Description of the Arc Plasma In a Magnetic Field, by D. Bohm. 18 p.**

A qualitative description of the new features of behavior of the arc plasma in a strong magnetic field is given. Experiments, which are described in more detail in other papers, are summarized here. The results indicate that the main unexpected result is the fact that electron and ion mobilities do not decrease as much as would be predicted by a simple theory from the small Larmor radii. This is explained in terms of drift of electrons and ions normal to magnetic field and plasma electric fields, which may be static or fluctuating. A general description of the balance between ion production and ion disposal as a result of motion in the existing fields is given, and it is indicated that the theory agrees with experiment, at least within an order of magnitude.

MDDC - 598 The Quantitative Estimation of the Activity of Beta Particle Emitters, by A. Broido, J. D. Teresi, P. Tompkins. 11p.

In estimating the activities of β-emitting materials used in the Biology Section, most measurements were made with Geiger-Mueller counters, although Lauritsen electroscopes were used in early work. All samples were mounted on flat porcelain capsules.

In the determination of absolute activity, errors arising from absorption and scattering were minimized by maintaining uniform conditions of measurement. Absolute standardization of the Geiger-Mueller counters was accomplished using both UX_2 and Ra E; and U_3O_8 reference standards were calibrated against the absolute standards. Methods of preparing the standards were developed. Values derived from the Ra E standards exceeded those from UX_2 by 8 per cent Using the ratio of the measured activity to the absolute activity of the standards, it was possible to correct the measured activities of unknown samples to absolute activities. It is probable that the uncertainty in the determination of the absolute activity value is less than ten percent.

Lauritsen electroscopes were calibrated against samples accurately measured with Geiger-Mueller counters. Sensitivites for various isotopes on the electroscopes used were of the order of one division per second per microcurie.

MDDC - 599 Disposal of Fluorine by Caustic Scrubbing, by W. B. Burford III. 8 p.

The disposal of waste fluorine, on a relatively large scale (in excess of 2 lb/hr) presented a number of difficult problems, especially in the presence of HF and large quantities of inert gas. Of the techniques which were readily available, caustic scrubbing seemed most satisfactory, since it provided a harmless gas effluent from the tower and did not require a vent for HF fumes, or the handling of aqueous HF solution. Early designs were unsatisfactory, either due to corrosion, accumulation of reaction products, or occasional violent reactions when a large quantity of fluorine reached the disposal apparatus.

A caustic scrubbing disposal tower for the safe removal of fluorine and/or HF from a gas stream is described and performance data are given. The unit was capable of handling fluorine in excess of 3 lb/hr, HF in excess of 5 lb/hr, and continued to function even when these gases were diluted four-fold with inert materials. The construction was simple, maintenance was reduced to a minimum, and materials used in the tower gave it a relatively long life.

MDDC - 600

Pilot Plant Synthesis of C_7F_{16}, C_8F_{16} and Fluorocarbon Oils Boiling up to 350°C, by W. B. Burford, 54 p. (See also Industrial and Engineering Chemistry Vol 39 p. 319-329, March 1947)

At the time of the discovery of the CoF_3 process for the production of perfluorocarbons*, great interest was aroused by the extremely stable characteristics of the fully fluorinated molecules, and technical samples were widely requested. To provide such samples, the laboratory synthesis was adapted to a continuous production cycle. It is the purpose of the present paper to describe the last and most successful modification of such a pilot plant, which was capable of producing materials whose boiling points ranged from that of o-n-butane (about -2°C) to perfluoro lubricating oils boiling above 350°C. The design, construction, and operation of a pilot plant for the production of perfluorocarbons by the CoF_3 process is described in detail. The process consists of passing vaporized hydrocarbon over CoF_3 powder at suitable temperatures, after which the resulting CoF_2 is regenerated with elementary fluorine.

The reacting equipment, fluorine cells, disposal system, and the production recovery systems are described in detail, and typical operational characteristics are outlined. A flow sheet is furnished to show schematically the interconnection of the various units.

A brief description is included of the ventilation system for the plant, operating personnel required to run it, and the normal output. In addition a brief characterization of some typical perfluorocarbons produced by the unit is included, with some physical properties of each material.

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* The term "perfluorocarbon" is applied to the completely fluorinated organic molecule, and for specific compounds, is usually indicated by the prefix "o", e.g., perfluoro n-heptane (n-C_7F_{16}) is written o-n-heptane.

MDDC - 601 Bioligical Bases for Maximum Permissible Exposures by S. T. Cantril, M. D. 63 p. August 9, 1946.

Contents: introduction; definiton of terms; history of the tolerance dose; legal status of tolerance dose; project radiation problems; the biologic aspects of the tolerance dose; radiosensitivity of tissues; general body effects; skin effects; effects on reproductive organs; radiogenetic effects; the dependence of tolerance dose on the nature of radiation; specific ionization: X-rays, gamma rays, beta rays, neutrons, alpha rays; combined radiations; specific tolerances of radioactive materials; radium and radon; the radioactive gases and vapors (xenon^{133}, iodine^{131}); mixed fission products (exclusive of plutonium in drinking water); plutonium tolerance levels; air contamination;the applicability of animal experimentation to radiation tolerances in man; tolerance levels for radiations and radioactive materials.

A list of 44 references is included.

MDDC - 602 Industrial Medical Program - Hanford Engineer Works, by S. T. Cantril, 28 p.

The Hanford Engineer Works, located at Richland, Washington, formed the production unit of the Plutonium Project. The Medical Department of the Hanford Engineer Works, under the direction of Dr. W. D. Norwood, had two primary divisions: the Village Medical Department which cared for the general medical services of employees and their families and the Industrial Medical Department which was concerned with the health and protection of the workers from any hazards peculiar to the operations. The Industrial Medical Department included the Health Instrument Section, under the direction of Mr. H. M. Parker.

It is the purpose of this memorandum to describe the functions of the Industrial Medical Department as organized and operated in this plutonium producing plant.

For statistical purposes this review covers a period up to August 1, 1945. It is concerned largely with those problems facing industrial medicine apart from physical monitoring carried on by the Health Instrument Section. Contents: introduction; organization and function; special industrial physicians; pre-employment examinations; location; function and description; criteria for acceptance and rejection of applicants;

Manual of standard practices for industrial nurses is added.

MDDC - 603 The Preparation of Cerium by Electrolysis of Molten Salts, by E. D. Eastman, B. J. Fontana, C. D. Thurmond, W. K. Wilmarth. 18 p.

Electrolysis of cerium chloride or fluoride in the potassium chloride-lithium chloride eutectic mixture, or of cerium chloride in the calcium fluoride-lithium fluoride eutectic at 850° to 1000°C produces cerium metal in clean ingots up to 80 per cent yield. Losses are chiefly due to oxyhalide formation in the presence of oxygen. In the absence of oxygen, losses are due either to the failure of finely dispersed metal to coagulate into the ingot or to the appreciable concentration of cerium salt in equilibrium with the bath in reactions of the type

$$Ce + KCl \rightleftharpoons CeCl_3 + 3K.$$

No direct evidence in proof of the latter concept is available. However, yields of over 90 per cent were obtained by electrolysis of cerium bromide in barium or strontium bromide. This is in agreement with a comparison of all the Periodic Group I and II halides based on the calculation of the extent of such equilibria from the available thermodynamic data.

MDDC - 604 Capture Cross Section of Pb^{208} for C Neutrons, by J. S. Levinger. 8p.

Using the method of induced radioactivity, the capture cross section of Pb^{208} for C neutrons is found to be $.00045 \pm .00015 \times 10^{-24}$ cm^2. This is definitely lower than the value of $.001 \times 10^{-24}$ reported by Maurer and Ramm. (Zeit f. Phys. V. 119, 602, 1942).

MDDC - 605 The Rate of Sublimation of Solids, by G. E. MacWood. 18 p.

The development of a theory of the rate of sublimation of solids is given and is compared with experimental results on uranium tetrachloride. The experimental approach to this problem is made difficult by the large number of possible variables involved. For this reason it was desirable to have a theoretical approach to the problem which takes account of first order effects.

Two different types of comparison are made with experimental results. In the first the calculated values of mass flux are compared with experimental values for two temperatures. It is observed that the general behavior is reproduced by the theory by simply varying one parameter (emissivity factor to take care of the non-blackness of the surfaces involved.) The second comparison with experiment involves an experiment suggested by the theoretical development, namely, measurement of the temperature gradient in the subliming solid. It is shown that the maximum temperature lowering of the surface is mainly in qualitative agreement with the theoretically predicated values.

MDDC - 606 Crystal Structure of Tetragonal Bismuth Arsenate, by R. C. L. Mooney.

The complete crystal structure of the tetragonal form of bismuth arsenate has been determined by X-rays. The crystal has the scheelite structure.

The body centered cell, containing four molecules, has the following dimensions

$a = 5.08 \pm .02$ A. U. $\quad c = 11.70 \pm .02$ A. U. $\quad c/a = 2.30$

The calculated density is 7.6 gm/cm^3
The space group is C_4h^6 - I $4_{1/a}$. The arsenic and bismuth are in fourfold special positions (a) and (b) of the space group, while the oxygens are in the sixteenfold general positions (f). The oxygen parameters, given in fractions of the unit cell, are

$x = 0.213 \quad y = 0.149 \quad z = 0.080$

Bismuth is in eight coordination, the average Bi-O distance being 1.54 A. U. Figure I is a projection of the structure of the basal plane.

MDDC - 607 Identification and Crystal Structure of Barium Hydrogen Phosphate, by R. C. L. Mooney. 11 p.

The report describes the complete structure of barium hydrogen phosphate, $BaHPO_4$, as determined by means of X-ray diffraction.

The crystal is orthorhombic, with cell dimensions given by

a = 5.71 A b = 7.05 A c = 4.61 A

The calculated density is 4.15 gm/cm^3 for two molecules in the unit cell.

The space group is C_{2v}^7-Pmn. The barium, phosphorus, and two sets of oxygen lie in the plane of symmetry. The third set of oxygens are in general positions. Parameters for these atoms have been found, and interatomic distances calculated. The positions of the hydrogens are indicated by the characteristic O-H-O distance (2.58 A) between two oxygens.

MDDC - 608 This document is temporarily unavailable.

MDDC - 609 Report on Determination of Densities of Several Uranium Compounds by H. F. Priest and G. L. Priest. 2 p. August 10, 1942.

It has been desirable from time to time to know the apparent, or packing, density, as well as the absolute density of uranium compounds. These values have been determined for UO_3, UO_2, UF_4 from two sources, and the packing density of UF_6.

In order to determine the packing density, the material was ground to pass a 120 mesh screen and a known weight placed in a conical graduated tube which was capped. This tube was then dropped a distance of 10 cm. in a guiding tube onto a 1'' rubber cushion. This packing was continued until there was no change in volume. This volume with the weight gave then the packing or apparent density. In the case of UF_6 this procedure had to be appreciably modified.

The absolute densities were determined by placing a known weight of compound in a pycnometer and adding alcohol of known density to the correct volume at 25°C. The weight was again obtained and from this data the absolute densities were calculated. The density of the alcohol was checked frequently to prevent error. The absolute density of solid UF_6 has not been determined as yet, due to the difficulty of finding a suitable liquid for use with UF_6. This problem has been solved but it will be some time before the density determination will be completed.

The following tables show the values obtained for the densities.

Material	Analysis	Absolute Density 25° C.	Packing Density 27.5°C.
UO_3	99.8	7.57	3.95
		7.51	
		Av. 7.54	
UO_2	99.34	10.26	4.96
		10.29	
		Av. 10.28	
UF_4 (wet method)	98.8	6.03	1.899
		5.99	
		Av. 6.01	
UF_4 (dry method)	99.1	6.42	2.997
		6.44	
		Av. 6.43	
UF_6	99.9		2.193

MDDC - 610 Report on Methods of Preparation of Inorganic Fluorides by H. F. Priest. 4 p. November 11, 1943.

Most of the common fluorides can be prepared in aqueous solution by a straight replacement or metathetical reaction.

Unfortunately the fluorides, when recovered from solution, are frequently hydrated, and their dehydration is a rather difficult problem. The hydrogen fluorine bond is such that the hydrates will usually lose HF instead of water with the formation of the oxide as follows:

$$MF_2.H_2O \xrightarrow{\Delta} MO + 2HF$$

Because of this reaction the anhydrous fluorides cannot be prepared by simply heating the hydrated forms. If it is desirable to form the anhydrous fluorides, the hydrated salt must be heated in an atmosphere of anhydrous hydrogen fluoride. This method has been used in some cases, and it has been found desirable to carry out the reaction in a nickel boat in a nickel reactor. Even under such conditions, the salt usually will show traces of nickel fluoride. The ideal condition would be where the boat and reactor were made of the same metal as that in the metal fluoride being prepared.

A second method is the reaction of metal oxides with anhydrous hydrogen fluoride. As mentioned in the above method, an excess of anhydrous HF prevents the formation of the oxide from the hydrated fluoride, and it should, therefore, be possible for the following reaction to take place:

$$MO + 2HF \xrightarrow{\Delta} MF_2 + H_2O$$

It has been applied to the preparation of both cupric and nickel fluorides. The reaction is unfortunately rather slow because the water forms a protective film over the partially converted oxide. However, if sufficient HF and time are available, this method will usually suffice to prepare anhydrous fluoride.

A third method which seems applicable is the reaction of metals with fluorine according to the following reaction:

$$M + F_2 \longrightarrow MF_2$$

While it is quite possible to prepare some fluorides by the direct synthesis method, it has not in general proved to be practicable.

A fourth method has proved successful and appears to be quite general. The reaction is very simple, being the replacement of chlorine in an anhydrous metal chloride as follows:

$$MCl_2 + F_2 \longrightarrow MF_2 + Cl_2$$

This method works very well for the preparation of most fluorides since it is usually possible to obtain the anhydrous chloride of a metal in a pure state. Traces of oxide impurity do not seem to harm the final product, the oxygen also being replaced by fluorine. Nickel, cobalt, calcium, cupric, silver, and aluminum fluorides have been prepared by this method. A nickel reactor has been used with no contamination of the product.

MDDC - 611

The Clinical Sequence of Physiological Effects of Ionizing Radiation in Animals by C. Ladd Prosser, et al. 31 p. (See MDDC-1066 for supplement. For general abridgement see also Radiology Vol. 49 p. 299-313, September 1947)

Researches in clinical physiology and biochemistry at the Metallurgical Laboratory have been concerned with (1) ascertaining whether different kinds of ionizing radiation have similar effects upon the mammalian body, (2) measuring sensitive reactions as a function of dose in the hope of setting permissible exposure limits, (3) searching for sensitive biological indicators of exposure, and (4) describing the course of radiation damage sufficiently to suggest profitable directions for research into mechanisms of radiation damage that might eventually lead to effective therapy. None of these objectives has been attained in a final form, but sufficient data are available to justify a summary at this time.

Four generalizations can be presented on the basis of the assembled evidence:

I. Every kind of ionizing radiation is similar in its clinical action whether it be penetrating external radiation or internal radiation from deposited material. By appropriate selection of doses, dose rate, and experimental animals, it has been possible to observe a similar clinical course with single and daily X irradiation, and with internal radiation from deposited alpha and beta emitters. Although it has not been studied in as great detail, the clinical pattern also appears to be similar after treatment with gamma rays, fast neutrons, and slow neutrons. External beta rays may cause skin effects similar to those produced by penetrating rays, but they probably kill by different mechanisms.

II. Nearly every organ system is affected by lethal doses of every type radiation. It has been known that the most sensitive systems are the blood forming organs, the gastro-intestinal tract, and the gonads. Peripheral circulation and heart are also affected. Terminally there may be damage to the kidneys and even to the central nervous system. Some of these effects are probably direct; and some indirect, as a result of toxic agents, or of hypoxia, infections and other secondary factors.

III. No single clinical reaction is peculiarly specific for irradiation damage. A similar preterminal course with leucopenia and high sensitivity of dividing cells is found with such toxic agents as the nitrogen mustards; the acute terminal course with fever is similar in acute infections and many diseases. There are striking similarities to anaphylactic shock and many of the delayed effects of irradiation can be duplicated by various toxic chemicals, e.g., anemia in benzol and phenylhydrazine poisoning and tumor induction by coal tar derivatives.

IV. The clinical picture and the conditions resulting in death vary with the dose rate and the duration of exposure for both external and internal radiation. If an animal survives one depression with a given set of symptoms it is likely to die later from a different mechanism.

MDDC - 612 The Use of Ion Exchangers for the Determination of Physical Properties of Substances, Particularly Radiotracers, in Solution. I. Theoretical, by J. Schubert. 20 p.

The exchange of cations by the synthetic resin cation exchangers is made the basis for numerous applications to physical chemical problems. Many of these applications require only radiochemical concentrations of an element. It is shown how it is possible to measure quantities such as the dissociation constants of complex ions and activity coefficients of electrolytes present in nearly zero concentration in the presence of macroscopic concentrations of another electrolyte. Additionally, a knowledge of the behavior of cation exchange systems is utilized for the detection and study of radiocolloids, the qualitative determination of the state of a radioelement in solution and the determination of the valence and basicity of cationic radioelements. There is reason to believe that the principles and methods developed with cation exchangers are applicable to anion exchangers.

MDDC - 613 Thermal Neutron Activation Cross Sections by L. Seren, H. N. Friedlander and S. H. Turkel. 43 p. (See also Physical Review Vol. 72, p. 888-901, Nov. 15, 1947).

The activation method of measuring slow neutron cross-sections is discussed, in connection with the survey made at Argonne Laboratory. A table is given listing 131 activation cross-sections of 65 elements and properties of the radio-isotopes produced. (This has also been abstracted as MDDC-408).

MDDC - 614 **Chemistry of the Fission Products, edited by N. Sugarman.**

This is chapter 7, Vol. 9B of the Plutonium Project Record and is made up of the following papers:

MDDC - 614A **Short-Lived Ge and As Fission Activities, by E. P. Steinberg, D. W. Engelkemeir. 15 p.**

Two Ge and two As activities have been found in fission with the following chain relationships:
12h Ge^{77} – 40h As^{77} – stable Se^{77}, fission yield = 0.0037 per cent for Ge^{77} total yield of As^{77} = 0.0091 per cent.
2.1h $Ge^{(78)}$ – 90m $As^{(78)}$ – stable $Se^{(78)}$, fission yield = 0.02 per cent.
the radiation characteristics of the Ge and As activities are: 12h Ge^{77}-, 1.8 Mev,γ ; 2.1h $Ge^{(78)}$-β , 0.9 Mev,γ; 40h As^{77}-β , 0.8 Mev; 90m $As^{(78)}$-β . 1.4 Mev, 4.1 Mev,γ.

MDDC - 614B **Absence of Long-Lived Ge in Fission, by L. Winsberg. 2 p.**

For assumed half-lives of Ge activities of 3d - 40y, the upper limit to the fission yield ranges from 10^{-4} per cent - 10^{-6} per cent.

MDDC - 614C **Absence of Long-lived As in Fission, by L. Winsberg. 2 p.**

For assumed half-lives of As activities of 3d - 1000 y, the upper limit to the fission yield ranges from 10^{-4} per cent - 5×10^{-8} per cent.

MDDC - 614D

Fission Yield of the 2.4h Br^{83} and Absence of Long-Lived Br by S. Katcoff, B. Finkle and N. Sugarman. 2 p.

An aliquot of an active UNH solution was analyzed for Br after the decay of the 30m Se parent. A stock solution of Br was made up, and aliquots were taken for chemical checks. The decay curve was followed over nine half-lives, and the measured half-life was 2.4h. No indication of the 4h Br period reported earlier was present, so that it must be concluded that this radioactivity does not exist and appeared at that time because of faulty chemical separations.

The fission yield found from this experiment is 0.30 per cent.

MDDC - 614E

Absence of Long-Lived Se in Fission, by L. Winsberg. 4 p.

For assumed half-lives of Se activities of 5h - 30y, the upper limit to the fission yield ranges from 2×10^{-4} per cent to $\sim 10^{-6}$ per cent.

MDDC - 614F

Short-Lived Kr and Xe Isotopes. Introduction, by R. M. Adams. 3 p.

There are essentially two methods of measuring the half-lives of the fission gases. The first is to collect the active gas and measure its half-life directly, and the second is to determine the spatial distribution in a flowing system of the radioactive decay products of the gases. The first method is obviously applicable only to the few long-lived fission gases.

The half-lives of some Kr isotopes have been determined by the direct method. Hoagland and Sugarman verified the half-lives of the 4.5h Kr^{85} and 74m Kr^{87} and also established a minimum value of ~10y for the half-life of the long-lived isomer of Kr^{85}. The two longer-lived Xe activities, Xe^{133} and Xe^{135} were also studied in this way, and the average half-life values found for Xe^{133} were 5.3d by Elliott, 5.21d by Freedman et al., and 5.5d by Engelkemeir and Sugarman. The half-life of Xe^{135} was most carefully obtained by decay measurements using an FP-54 circuit and ionization chamber, and the average value found by this method was 9.14h.

MDDC - 614G

Search For Gas Ancestry of Some Fission Products, by E. L. Brady and N. Sugarman, 3 p.

Although this experiment was largely explanatory and no attempt was made to measure half-lives, it is given in some detail since it determined the gaseous ancestry of four chains not previously recognized to have gaseous ancestors; namely, chains leading to the 2.7h Sr, 11h Y, 32h Ce, and the 4.5h Pr^{145}.

CHAINS WITH GASEOUS ANCESTRY

(a) Kr→Rb→2.7h Sr→3.5h Y
(b) Kr→Rb→8.5h Sr → 50m Y / 57d Y
(c) 2m Kr^{89}→15m Rb^{89}→55d Sr^{89}
(d) Kr→Rb→Sr→11h Y→Zr
(e) 0.5m Xe^{140}→40s Cs^{140}→300h Ba^{140}→44h La^{140}
(f) 0.5m Xe^{139}→7m Cs^{139}→86m Ba^{139}
(g) 6.6h I^{135}→9.4h Xe^{135}→30y Cs^{135}
(h) Xe→Cs→Ba→La→32h Ce→12d Pr
(i) Xe→Cs→Ba→5.3h La*

Special case: (j) 6.6h I and longer-lived I periods
Not examined: (k) 3h Kr→18m Rb
(l) 10m Sb^{133}→22h I^{133}→5.4d Xe^{133}
(m) 17 m Xe→33m Cs

*Ed. Note. This activity has since been shown to be the 4.5h $Pr^{(145)}$ (3)

MDDC - 614H

Half-lives of Some Short-lived Krypton and Xenon Activities by C. Dillard, R. M. Adams, H. Finston and A. Turkevich. 3 p.

The technique used by Brady and Sugarman was modified in order to establish the presence of noble gas members of fission chains and also to determine their half-lives. The general procedure was as follows:

A stream of nitrogen gas was passed through a solution of UNH which was being bombarded with slow neutrons, then through a series of tubes filled with glass wool, and finally into a charcoal trap which was cooled in liquid nitrogen. The gaseous fission products formed in the solution were swept out with the nitrogen, and the decay products of the shorter-lived gases were deposited on the glass wool; the longer-lived gases were adsorbed on the charcoal and decayed there. After the bombardment the glass wool from each section of glass tubing was leached with successive portions of hot 6N nitric acid until greater than 99 per cent of the activity was removed. The several nitric acid solutions were then made up to known volumes, and aliquots were taken for radiochemical analyses. The charcoal was treated in the same way.

As the radioactive gases are swept through the adsorption column, their decay products are deposited exponentially on the glass wool according to the half-life of the particular gas. Therefore by ascertaining the distribution of any decay product along the glass wool, and knowing the rate of gas flow, one is able to determine the half-life of the parent gas.

The table gives the results of these experiments and represents the knowledge of half-lives at the time. Some of the half-lives have subsequently been revised.

TABLE

Rare Gas	Activity Identified	Estimated T 1/2 of Gas
Kr^{89}	55d Sr	3 min
*Kr^{90}	60h Y	short
Kr	57d Y	~6 sec
Kr	11h Y	1-2 sec
Xe^{140}	12.5d Ba	~6 sec
Xe^{141}	28d Ce	short
*Xe	17m Pr	short

* These chains were not previously known to have gaseous members.

MDDC - 614I **Determination of Gas Half-lives by the Charged Wire Technique, by R. Overstreet and L. Jacobson. 3p.**

Table gives half-lives of the gases as determined in this experiment. Some of the values may be subject to rather large errors because of the low activities encountered.

Fraction	Half-Life of Gaseous Ancestor
Ba^{140}	9.8 seconds
Ce^{141}	1.7
Y (57d)	5.7
Zr (? 20d)	3.1
Sr^{89}	33
Pr^{143}	<0.2 second

MDDC - 614J **Determination of Gas Half-lives by the Charged Wire Technique. II. by C. Dillard, R. M. Adams, H. Finston and A. Turkevich. 14 p.**

In these experiments the charged wire technique was used for the determination of half-lives of the short-lived fission gases.

HALF-LIFE VALUES OF THE SHORT-LIVED GASES FORMED IN FISSION

Noble Gas Isotope	Daughter Activity Identified	Half-life of Gas
Kr^{89}	55d Sr^{89}	155 ± 5 sec
Kr^{90}	~30y Sr^{90}→60h Y^{90}	~25 sec (estimated)
Kr^{91}	9.7h Sr^{91}	9.8 ± 0.5 sec
$Kr^{(92)}$	3.5h $Y^{(92)}$	3 ± 0.5 sec
Kr^{95}	11h $Y^{(95)}$	2 ± 0.5 sec
*Kr^{97}	17h Zr	~1-2 sec (estimated)
Kr parent of 20m Y	20m Y	1.4 ± 0.5 sec
Xe^{139}	85 m Ba^{139}	41 sec
Xe^{140}	12.5d Ba^{140}	16 ± 0.5 sec
Xe^{141}	28d Ce^{141}	3 ± 1 sec**
Xe^{143}	33h Ce^{143}	1 ± 0.5 sec
Xe^{144}	275d Ce^{144}→17.5m Pr^{144}	~1 sec (estimated)
Xe parent of 1.8h Ce	1.9h Ce	0.8 ± 0.5 sec

* This chain was not previously known to have a gaseous member.

** Ed. Note. A more recent determination of the half-life by Katcoff and Goldstein is 1.75.

MDDC - 614K **Discovery of ~10y Kr^{85} in Fission by E. J. Hoagland, N. Sugarman. 9 p.**

A long-lived Kr of ~10y half-life has been found in fission. Its mass assignment is 85. The characteristics of the ~10y Kr^{85} are: β, 0.074 Mev; No γ; fission yield, ~ 0.24 percent.

MDDC - 614L **Quantitative Studies of the Neutron Activation of Kr by E. J. Hoagland and N. Sugarman. 14p.**

Cross-section values for formation of 4 Kr isotopes are reported. Beta energies of two Kr isotopes (34h $Kr^{79, 81}$ 4.5h Kr^{85}) have been determined and shown to be in rough agreement with the literature values: γ radiations of these isotopes have also been detected and their energies measured. The long-lived fission Kr activity has been prepared by neutron bombardment of Kr; its mass assignment from these experiments must be either 85 or 87. From other experiments it has been shown to be 85.

Table I

Isotope	σ (for formation from natural element)	σ (isotopic) Target nucleus	σ	β radiations (Mev)	γ radiations (Mev)
34h $Kr^{79,81}$	0.00090 B	78	0.27 B	0.6 (70%)	0.2
		80	0.047 B	0.9 (30%)	0.5 (annihilation)
4.6H Kr^{85}	0.056 B	84	0.096 B	1.0	0.17, 0.37
~10y Kr^{85}	0.036 B	84	0.062 B	0.8	no γ
74m Kr^{87}	0.011 B(a)	86	0.061 B(a)	4.0	---

(a) These values are considerably more uncertain than the others in the table since the activity of the 74m Kr was only 10 percent of the total activity at the time the decay curve was started.

MDDC - 614M **Characteristics of 2.7h $Sr^{(92)}$. 1 p.**

The 2.7h isotope of Sr was first reported by Götte.

Its probable mass assignment is 92, since 90 and 91 have been definitely established as assignments of ~25y Sr and 9.7h Sr respectively.

The Kr ancestry of 2.7h Sr has been demonstrated by Sugarman and Brady, and the Kr half-life has been reported as 3 ± 0.5s by Turkevich and co-workers.

The fission yield of 2.7h Sr in U has not been directly determined, but experiments by Hoagland and Katcoff measured the yield of 3.5h Y which had grown from an active Sr sample. Results indicated a fission yield of 5.1 per cent for 2.7h Sr.

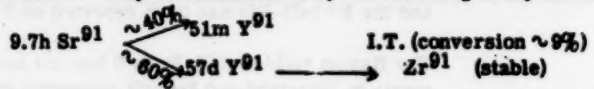
MDDC - 614N **Fission Yield and Radiations of The 3.5h $Y^{(92)}$, by E. J. Hoagland, S. Katcoff. 3p.**

The U fission yield of 3.5 h$Y^{(92)}$ isolated from its 2.7h $Sr^{(92)}$ parent is found to be 5.1 per cent. From a Feather analysis of the Al absorption curve of the radiations of 3.5h Y, the maximum β energy is found to be 3.5 Mev, in agreement with the literature value of 3.6 Mev.

MDDC - 614O

The Characteristics and Decay Relationships of 9.7h Sr^{91} and 51m Y^{91}, by B. Finkle, S. Katcoff, N. Sugarman. 16 p.

The half-life of Sr^{91} was found to be 9.7h from an analysis of both β and γ decay curves. Absorption measurements in Al and Pb indicate the presence of two β radiations - 1.3 Mev and 3.2 Mev, roughly in equal amounts, and a γ-ray of $\sim$1.0 Mev in energy. The branching of Sr^{91} to the isomeric pair 21m Y^{91} and 57d Y^{91} may be summarized by the following decay scheme:



The γ energy of 51m Y^{91} was found to be $\sim$0.6 Mev from e^- and γ absorption measurements.

MDDC - 614P

Fission Yield of 20m Y, by C. R. Dillard, R. M. Adams, H. Finsten, A. Turkevich. 3 p.

A decay curve of Y activities obtained by rapid analysis of UNH shows the presence of the 20m Y reported by Hahn and Strassmann. A preliminary value of the fission yield is calculated to be 5 ± 1 per cent.

MDDC - 614Q **Energies of Radiations of 17h $Zr^{(97)}$ and 75m $Cb^{(97)}$, by S. Katcoff, B. Finkle. 5p.**

The maximum β energies of 17h Zr and 75m Cb as obtained by Feather analysis of the Al absorption curves are 2.2 Mev and 1.4 Mev, respectively. The literature values are 1 Mev for each of the isotopes. The γ energy as determined from a Pb absorption curve is $\sim$ 0.8 Mev for both isotopes.

MDDC - 614R **The Discovery of Long-lived Zr and Cb in U Fission, by B. L. Goldschmidt, I. Perlman. 3 p.**

An isotope of Zr of about two months half-life and one of Cb of about one month half-life not previously reported in fission mixtures have been found.

MDDC - 614S

The Characteristics of the 65d Zr By Chemical Study, by E. L. Brady, D. W. Engelkemeir, E. P. Steinberg. 7 p.

A detailed study of the radiations of the long-lived Zr has been made. This isotope is characterized by soft β radiation, fairly hard γ radiation and the growth of a long-lived Cb daughter, as reported by Goldschmidt and Perlman.

MDDC - 614T

A Note on the β and γ Energies of 65d Zr and 35d Cb by Coincidence Counting by A. C. G. Mitchell and L. J. Brown. 2p.

The energy of the γ rays of a sample of 65d Zr was determined by measuring the range in Al of Compton electrons ejected from Al, in a coincidence apparatus. The range was $0.275 \pm .025$ gm/cm^2 corresponding to an energy of $0.600 \pm .050$ Mev.

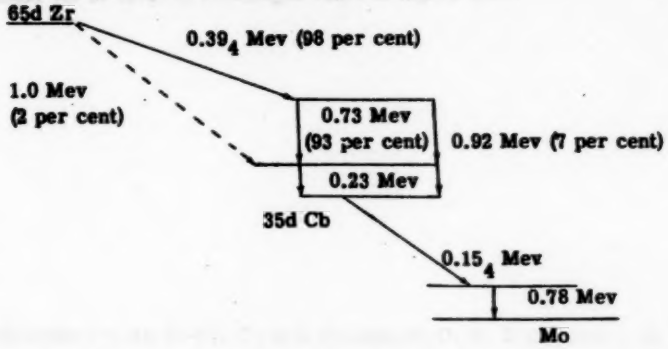
Tests were made for γ- γ and β- γ coincidences. There were no γ- γ coincidences, indicating the presence of only one γ ray. There were no β- γ coincidences beyond 0.1 gm/cm^2, but for thickness less than this the β- γ coincidence rate increased. Assuming that the sample is pure, this indicates that the β-ray spectrum is complex with an inner end point at 400 kv in addition to the high energy group and the γ ray.

In the case of 35d Cb, the range of the Compton electrons was 0.260 gm/cm^2. This corresponds to a γ-ray energy of 0.575 Mev.

MDDC - 614U The β-Ray Spectrum of 65d Zr by V. A. Nedzel. 3 p.

The spectrum of a Zr source freshly purified from Cb has been studied with the 180° β-ray spectrometer. Two continuous spectra and four conversion lines were found. The continuous spectra end points are at 0.39_4 Mev and at 1.0 Mev, with their relative abundances as 98 to 2.

γ energies are obtained as $0.21_5 + 0.019 = 0.23_4$ Mev, 0.71 + 0.019 = 0.73 Mev, and 0.09 - 0.019 = 0.92 Mev. Although the 1.0 Mev end point is only poorly determined and the 0.92 Mev is somewhat doubtful, the following disintegration scheme is offered as a suggestion:



MDDC - 614V The Characteristics of 35d Cb By Chemical Study, by D. W. Engelkemeir, E. L. Brady, E. P. Steinberg. 8 p.

The radiations of the long-lived Cb daughter of 65d Zr have been studied and found to agree in general with the characteristics reported by Goldschmidt and Perlman, namely, a very soft β and a hard γ.

MDDC - 614W

A Note on the Spectrum of 35d Cb by Coincidence Counting by D. W. Engelkemeir. 3 p.

Measurements of β - γ coincidences in a sample of 35d Cb have been made, using an apparatus consisting of a two-fold coincidence circuit with a resolving time of $2T = 7.5 \times 10^{-8}$ minutes. Results are plotted.

Samples of the same 35d Cb activity were submitted for examination on the magnetic spectrograph. The results indicate the presence of a disintegration β spectrum with no trace of the internal conversion line at 0.15 Mev which should be present if the correct mass assignment is mass number 93. This lends weight to other arguments in favor of the mass assignment as 95.

MDDC - 614X

The β Ray Spectrum of 35d Cb by V. A. Nedzel. 3 p.

The spectrum of 35d Cb has been studied with the 180° β-ray spectrometer. The spectrum consists of a continuous group of β's with end point at 1420 Hρ (gauss-cm) or 0.15_4 Mev. Three conversion lines were observed at 1710 Hρ, 0.21_3 Mev; at 3560 Hρ, 0.75_5 Mev; and at 3930 Hρ, 0.77_4 Mev. The last two are probably related as K and L electrons; and if they arise from Mo, then the energy is $0.75_5 + 0.020 = 0.77_5$ Mev or $0.77_4 + 0.003 = 0.77_7$ Mev. If the first line is due to K electrons from Mo also, then the γ associated with the line is $0.21_3 - 0.020 = 0.23_3$ Mev.

A little over a month after the first measurements were made, the Cb was surveyed again. Due to the decay of the source, only the continuous spectrum and the most prominent line were observed, and both of these dropped in intensity an amount consistent with about a one month half-life. After this measurement, the decay of the Cb source was followed for two months in an electroscope. The decay period observed was about 40d, in good agreement with the accepted 35d half-life and confirming that the source was mostly 35d Cb.

MDDC - 614Y — The Mass Assignment of The Chain 65d Zr—35d Cb, by L. Jacobson, R. Overstreet 7 p.

The mass of the 35d Cb has been established as 95 by bombardment of Zr and Mo with 16 Mev deuterons.

MDDC - 614Z — The Existence of An 80-85h Cb in U Fission, by D. W. Engelkemeir, E. L. Brady. 4 p.

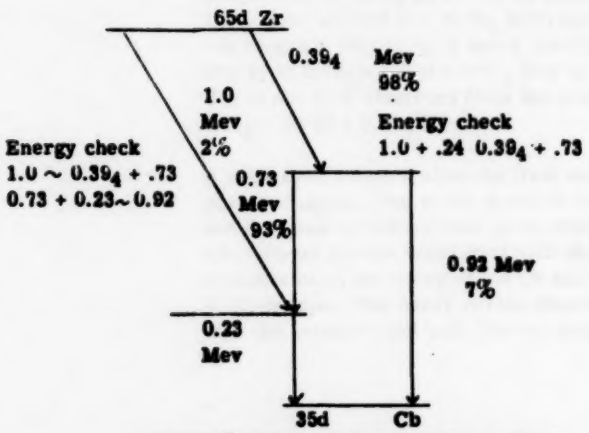
An isotope of Cb of 80-85h half-life, not previously reported, has been found among the fission products. This isotope was discovered during the study of the 35d Cb.

MDDC - 614AA **The Characteristics of The 90h Cb^{95} By Chemical Study. 8 p.**

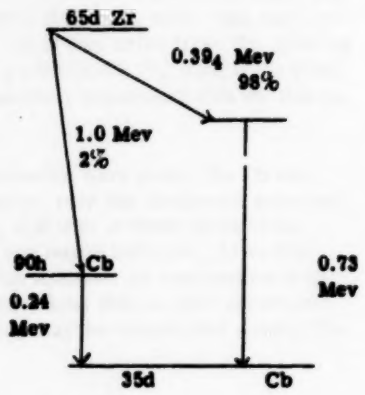
The half-life of 80-85h Cb is shown to be more nearly 90h. Its parent is a Zr of ~65d half-life, and its radiations are an X-ray and a conversion electron arising from a decay by isomeric transition to 35d Cb. The γ ray giving rise to the conversion electrons has an energy of ~0.2 + Mev and appears to be almost completely converted.

MDDC - 614BB **Preliminary Spectrometer Examination of 90h Cb, by J. S. Levinger. 10 p.**

A spectrometer examination of the 90h Cb was made on the β and γ spectrometer constructed by Nedzel. Preliminary results on this activity which grows from the 65d Zr^{95} are given.



Nedzel's proposed disintegration scheme



A possible variation by Levinger and Steinberg

MDDC - 614CC Absence of Long-Lived Rh In Fission, by J. A. Seiler, L. Winsberg. 3p.

For assumed half-lives of Rh activities of 10d - 20y, the upper limit to the fission yield ranges from 4×10^{-4} per cent to 5×10^{-6} per cent.

MDDC - 614DD Pd-Ag Chains In Fission, by J. A. Seiler. 14 p.

The isotopes of Pd and Ag, 13h $Pd^{107,109}$, 21h Pd^{112}, and 3.2h Ag^{112}, known from cyclotron bombardments, have been found in U fission by pile neutrons. Careful analysis of the decay curves has led to a longer half-life for Pd^{112} (reported as 17h in the literature). The radiations of the isotopes are as follows: 13h $Pd^{107,109}$ - β, 1.1 Mev, no detectable γ; 21h Pd^{112} - β 0.2 Mev, no detectable γ; 3.2h Ag^{112} - β 3.6 Mev, γ, 0.86 Mev. The fission yields of the 13h Pd and 21h Pd are 0.017 per cent and 0.011 per cent, respectively.

MDDC - 614EE Absence of Long-Lived Pd Isotopes in Fission, by J. A. Seiler. 2 p.

For assumed half-lives of Pd activities of 2d -1y, the upper limit to the fission yield ranges ranges from 10^{-4} - 5 x 10^{-6} percent.

MDDC - 614FF Study of The 43d Cd^{115} In Fission, by R. P. Metcalf. 4 p.

The 43d Cd^{115} isotope formed by neutron bombardment of Cd has been found in pile fission. The maximum β energy as found by a Feather analysis of the Al absorption curve was 1.85 Mev.

The fission yield of 43d Cd^{115} was found to be 0.0008 per cent.

MDDC - 614GG The Chain 2.33d Cd^{115} - 4.5h In^{115} by R. P. Metcalf. 10 p.

The 2.33d $Cd^{115} \rightarrow$ 4.5h In^{115} chain has been found in pile irradiated UNH. The β energies of 2.33d Cd were found to be 1.25 Mev and 0.55 Mev, in good agreement with the published literature values.

The fission yield of the chain was found to be 0.011 per cent; the yield for mass 115 is thus the sum of this yield and that of 43d Cd, i.e., 0.012 per cent.

MDDC - 614HH The Chain 2.83h Cd^{117} - 1.95h In^{117} by R. P. Metcalf. 6 p.

The 2.83h $Cd^{117} \rightarrow$ 1.95h $In^{117} \rightarrow$ stable Sn^{117} chain has been found in UNH irradiated at Chicago heavy water pile. The energies of the radiations of the Cd isotope were not obtained because of the complexity of the absorption curve. The maximum β energy of 1.95h In^{117} was found to be 1.95 Mev from an Al absorption curve. The fission yield of the chain is 0.010 per cent.

MDDC - 614II Sn Isotopes In Fission, by J. A. Seiler. 12 p.

Three Sn isotopes have been found in U fission by pile neutrons. These isotopes are probably identical with those found in cyclotron fission. Their radiations are as follows: 80m Sn-β, 2.8 Mev, 0.7 Mev, (it is thought that one of these β rays may be due to an Sb daughter), γ, 1.2 Mev; 62h Sn-β 0.8 Mev, 10d Sn-β, 2.6 Mev. The fission yields are: 80m, ~0.1 per cent; 62h, 0.014 per cent; 10d, 0.0044 per cent.

MDDC - 615 The Toxicology of U-Compounds - - Progress Report on Injection and Ingestion, by A. Tannenbaum, H. Silverstone. 36 p.

The report concerns itself with the toxicology of U compounds when injected or fed to mice. The criteria of toxicity were: appearance of mice, weight changes, gross and microscopic pathological changes, and mortality. The U content of the organs and tissues were determined.

On subcutaneous injection, U compounds are very toxic. Depending on the particular strain of mouse utilized in the experiment, a single subcutaneous injection of 0.5 to 2 mg of U as the nitrate, produced mortality in some members of a group; 4 mg was lethal to all mice. Strain is a modifying factor in toxicity, while age and sex play less important roles.

Injections of the above-mentioned amounts of U produced an acute intoxication: the most constant and striking pathological change was an acute necrotizing nephrosis. The deaths occurred during the acute intoxication (first two weeks); otherwise, the mice recovered more or less completely. The main sites of U accumulation are the kidneys and bone. Disappearance from these organs is a slow process. U is excreted in the urine and feces.

In the ingestion experiments the U compound was incorporated into the diet. Daily dosages of 10 mg of U as the nitrate produced relatively low toxicity and no mortality, while dosages of 80 mg of U daily were toxic and lethal. It is clear that the relatively low toxicity of U compounds on ingestion (compared

(Cont'd on next page)

MDDC - 615 **The Toxicology of U-Compounds -- Progress Report on Injection and Ingestion, by A. Tannenbaum, H. Silverstone. 36 p. (Cont'd from page 392)**

with injection) is due to the low rate of absorption of these compounds from the gastrointestional tract. The nature and duration of the intoxication, the gross and microscopic pathological changes and the distribution of U in the tissues were all similar to that found in the injection studies. U accumulates slowly in the kidneys and bone, and disappears slowly after the removal of U from the diet.

Studies on comparative toxicity reveal that the following compounds may be grouped with regard to their toxicity on ingestion:

UO_2, U_3O_8, UF_4 -- non-toxic.
UO_3 -- toxic in high doses.
UCl_4 -- non-toxic in moderate doses; toxic in high doses.
$UO_2(NO_3)_2$, UO_4, $Na_2U_2O_7$ -- toxic in moderate doses.
UO_2F_2 -- toxic, even at relatively low dosages.

In considering the toxicology of U compounds it is necessary to clearly distinguish between exposure to U, absorption of U, the presence of U in the tissues, and U toxicity. The lack of relationship of the amount of U in the tissues and the state of intoxication at any one time is discussed. It is suggested that the acute intoxication be considered apart from the subsequent course. The significance of the anions of the ingested compound is discussed. For example, it is probable that UO_2F_2 is more a problem of F toxicity than U toxicity. The course of chronic U poisoning is still to be recognized and described.

MDDC - 616

Methods of Analysis of Fission Products in the Experimental Biology Section, by P. C. Thompkins, A. Broido, L. Wish. 12 p.

This report describes methods used for radiochemical analysis of fission products most used in the Experimental Biology Section. The report includes methods of analysis of Sr^{89}, Ba^{140}-La^{140}, Zr^{95}-Cb^{95}, Ce^{144}-Pr^{144}, and Y^{91} by standard chemical procedures. In addition, a method of analysis by use of an absorption curve is described in some detail for Zr^{95}-Cb^{95} mixtures. The absorption curve method makes possible rapid determination of percentage composition of a mixture of isotopes with a minimum of chemical manipulation by utilizing the differences in absorption characteristics of the emitted rays.

MDDC - 617

Magnetic Moment of the Triton by H. L. Anderson and A. Novick. 12 p. Jan. 6, 1947. (See also Physical Review Vol. 71 p. 372-373, March 15, 1947)

The ratio of the nuclear (g) values of the triton and the proton by the method of nuclear induction has been measured. The nuclear induction peaks of both the triton and the proton were observed simultaneously on the same cathode ray oscillograph screen while both these substances were in the same magnetic field.

A description of the equipment and method is presented. Resulting ratio gives 1.0666 ± 0.0001.

The fact that the nuclear (g) value of the triton is larger than that of the proton disagrees with the estimate of Sachs and Schwinger based on the wave function obtained by Gerjuoy and Schwinger. In fact, it shows that the admixture of $^4D_{1/2}$ wave functions to the ground state of the triton is not sufficient to account for its magnetic moment.

MDDC - 618 Spin and Magnetic Moment of Tritium by F. Bloch, A. C. Graves, M. Packard, R. W. Spence. 8 p. (See also Physical Review Vol. 71 p. 373-374, March 15, 1947)

Nuclear induction has been applied to a small sample containing a 0.3 molar solution of Mn SO_4 in H_2O and clearly distinguishable signals have been obtained from both hydrogen isotopes, H_1 (proton) and H_3 (triton) present in the sample. A density determination indicated that about 80 percent of the hydrogen was present in the form of H_3 and about 20 percent in the form of H_1.

A first series of observations was performed by keeping the frequency constant at V = 41.5 megacycles and merely varying the magnetic field B_o. The signal originating from H_3 appeared at a field B_o = 9160 gauss and except for being about three times larger had an identical sign and shape as the signal originating from H_1, which appeared at a field B_o = 9770 gauss. It leads to the following conclusions:

a) The gyromagnetic ratio γ_T of H_3 is about 7 percent larger than γ_P, the gyromagnetic ratio for H_1 as indicated by the ratio of the respective resonance fields B_o.
b) Within the observational error of about 30 percent the magnitude of the signals agrees in their ratio with the ratio of the respective amounts of the two isotopes. This shows that the spin of H_3 is the same as that of H_1 which is known to be 1/2. A spin of 3/2 or more for H_3 would have resulted in a five times larger signal relative to that of H_1, than was observed and could therefore be definitely excluded.
c) With the signals which originate under identical radio frequency conditions from the two isotopes having the same sign, the relative orientation of their magnetic moments and angular momenta is the same. Since H_1 is known to have a positive magnetic moment, H_3 has therefore likewise a positive moment.

To summarize, it can be stated that the triton has a spin of 1/2 and that its magnetic moment is positive and 1.067 ± 0.001 times larger than that of the proton.

MDDC - 619 The Peroxy Complexes of Plutonium (IV), by R. E. Connick, W. H. McVey. 38 p.

Two peroxy complexes of Pu(IV) have been identified in aqueous solution and their composition determined. The equilibria of these ions with hydrogen peroxide and Pu^{+4} were measured spectrophotometrically as a function of the H_2O_2, plutonium and H^+ concentrations and formulas of the ions were deduced from these data. The first complex, which is brown in color, contains two plutoniums, one peroxide ion and probably one hydroxide group. The second complex, which is red, is made up of two plutoniums and either two peroxide ions or one perhydroxide ion and a hydroxide ion. Possible structural formulas for the complexes are presented. Attention is called to the remarkable fact that both complexes contain two plutonium ions and that no evidence was obtained for complexes involving only one plutonium ion.

MDDC - 620 The Synthesis of 1, 2, 5, 6-Dibenzanthracene Labeled in the 9-Position with Carbon-14 by C. Heidelberger, P. Brewer, and W. G. Dauben. 8 p. (See also JOURNAL OF THE AMERICAN CHEMICAL SOCIETY Vol. 69, p. 1389-1391. June, 1947).

The CO_2 from $BaCO_3$ (94,500 counts/min./mg $BaCO_3$) and 2-$C_{10}H_7$-MgBr give 73% (on basis of CO_2) 2-$C_{10}H_7C14O_2H$, m.p. 181-183.50, specific activity x 11 = 93,800 cts./min./mg. $BaCO_3$; this gives 80% 1-(2-naphthoyl)-2-methylnaphthalene, b.p 212-215°/0.5 m; pyrolysis of 1.25 g. 3.5 hrs. at 435° gives 9-labeled 1,2,5,6-dibenzanthracene (I), m.p. 259-262°, 11% (on basis of $BaCO_3$), specific activity x 22 = 94,000 cts./ min./ mg. $BaCO_3$ or 67,000 cts./min/mg. I (0.385 microcuries/mg.). Some of the extensive decomposition that occurs during the Elbs reaction involves volatilization of the carbonyl C atom. In the reaction, 40% of the original radioactivity was recovered.

MDDC - 621 **Experience with Ionization Chamber Technique with C^{14} Activity, by C. D. Janney and B. J. Moyer. 6 p. January 18, 1947.**

For biological problems at Berkeley, involving large dilutions of carbon activity, use is being made of the ionization chamber method similar to that employed at Harvard (Henriques) and at Chicago (Jesse, et al).

C^{14} is introduced into the ionization chamber as CO_2. Currents are read with Lindemann electrometer, either by rate of drift method or by a null method. Data and physical reasons show the latter method preferable. The chamber volume employed is about 100 cm^3 and contains about 50 mg of carbon.

Performance is discussed with regard to background current and dilution tests; comparison is made with thin window Geiger counter results; spurious effects to be overcome or avoided are considered.

Summary indicates:

(1) Typical background current 2 - 3 x 10^{-16} amp., read to $\pm$ 10% in 20 - 30 minutes.

(2) Limitations on accuracy are accounted for by the statistics of disintegration events.

(3) A typical dilution of C^{14} has an activity-to-background ratio in this method about 200 times the ratio for the same dilution when counted by a thin window Geiger counter. This assumes that sufficient sample is available for optimum use of each instrument. Larger samples are needed for optimum use of electrometer by a factor of from 10 to 20.

MDDC - 622 **Ionization Chamber Techniques in Measurement of C^{14}, by W. P. Jesse, L. A. Hannum, H. Forstat, A. L. Hart. 13 p. January 1947.**

In connection with work on the measurement of C^{14} samples, it seemed desirable to determine the limit of sensitivity of the ionization chamber method for such measurements. Two instruments were used to measure the change accumulated on the electrode of the chamber in a given time. One of these was the vibrating-reed electrometer; the other was an electrometer of the Lindemann type, constructed in the Ryerson Shop.

The vibrating-reed electrometer is a dynamic condenser type of electrometer, developed at the Metallurgical Laboratory during the war. The principle of operation of this instrument is indicated. The detailed circuit is shown.

With the Lindemann type electrometer, the travel of the index pointer of the needle was observed with a microscope and scale in the usual way. The method used was, however, a null method in which the pointer was brought back to the zero position by a charge of the opposite sign induced on the system.

A few measurements were made on thin solid samples of C^{14} obtained by evaporating on aluminum plates very dilute active solutions of sodium carbonate and sodium acetate. These samples were measured in an air ionization chamber shielded by $1\frac{1}{2}$ inches of lead.

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MDDC - 622

Ionization Chamber Techniques in Measurement of C^{14}, by W. P. Jesse, L. A. Hanmum, H. Forstat, A. L. Hart. 13 p. January 1947. (Cont'd from page 397)

No very extensive measurements were made with solid samples and none at all with thick samples. Consistency tests with very thin samples indicated that, with a twenty-minute run for the sample and a twenty-minute run for the background, measurements consistent to within 10 per cent could be made with an activity in the sample of about one beta disintegration per second. This corresponds to about the background current of the ion chamber. All these measurements were made with the vibration-reed electrometer although the Lindemann electrometer could also have been adapted to such use.

More extensive tests were made as to the ultimate sensitivity of the ionization chamber method with gaseous samples of CO_2. The use of the gas, of course, eliminates the troublesome absorption corrections which must be made with solid samples.

Results are tabulated and interpreted for consistency by statistical methods. Circuit diagrams, charts and a photograph are included.

MDDC - 623

Photographs No. 184 - 584, 588, 591. 593 and Lin. Ac-205, 262, 263, Radiation Laboratory. 7 p.

Drawings.

184" Cyclotron: Inside the vacuum tank are positively charged nuclear particles (deuterons) entering at the center and revolving in a uniform magnetic field; as the energy increases, in step with the oscillating voltage on the "dee" these particles spiral outward. The energy gain is 20,000 electron volts per revolution tion; thus, it takes 10,000 revolutions to reach 200 Mev. At this energy particles are moving at 80,000 miles per second, or 43% the velocity of light.

The deuterons, as they approach the velocity of light, increase in mass (relativistic effect). To prevent the particles from lagging, and so failing to be accelerated, the oscillating frequency of the dee voltage is continuously changed. Thus the terms "frequency-modulated" (or FM) cyclotron, or "synchrocyclotron".

184" cyclotron: Cut-away to show interior ; view from north; view from northeast.

Linear accelerator: cut-away views.

Van de Graaff generator: cut-away view.

MDDC - 624 General Electric Company's Part in Manhattan District Electromagnetic Process by T. R. Rhea. 10 p.

General Electric participated to the extent of about 3½ per cent of the total expenditure by the country. Most of the equipment furnished required a very high order of technical and engineering skill.

Its performance must be credited primarily to the facts that top management gave the project No. 1 priority rating within the Company and that the production departments appreciated the importance of the work.

There were three general types of special process equipment required for the project: (1) process power-supply equipment, (2) magnet coils, and (3) production calutron equipment. All these required special engineering and skill of design, special manufacturing facilities, and maximum accuracy. After a careful study, the Stone and Webster Engineering Corporation recommended to the War Department that more rapid progress would result if one manufacturer concentrated efforts on a given item. This recommendation was accepted by the Corps of Engineers, and the General Electric Company was thereupon requested to develop and produce the power-supply equipment. Development and manufacture of the calutron production equipment was assigned to the Westinghouse Electric Corporation, and the magnet coils to the Allis-Chalmers Manufacturing Company.

The story of General Electric's part is carried out under the following topics: early problems; field engineering and research; electronic tubes by the thousands; field engineering and research; dates of orders.

MDDC - 625

On the Magnetic Moment of Tritium by R. G. Sachs. 2 p. (See also Physical Review Vol. 71 p. 457 April 1, 1947).

The recent determination of the magnetic moment of tritium by Anderson and Novick (MDDC-617) leads to the somewhat surprising result that the moment is slightly greater than the proton moment. This result is surprising because the moment in a ^2P or ^4P or ^4D state, which are the only states that can be admixed with the ^2S state of tritium, might be expected to be smaller than the proton moment. Therefore, one might expect that any admixture of these states would lead to a smaller moment than that in the pure S state.

It is possible to account for the moment of tritium by introducing an admixture of ^2P and ^4P states since there are terms in the expression for the magnetic moment which arise from interference between the ^2P and ^4P states and from interference between the ^4P and ^4D states. The signs of these terms depend on the relative phases of the wave functions so that they may be positive. An estimate of their order of magnitude can be made if one makes assumptions consistent with keeping the orbital angular momenta of the individual particles as small as possible and at the same time assumes that the radial parts of the various wave functions are in phase throughout the nucleus. Then it is found that a 5% increase of the tritium moment over the proton moment can be obtained by an admixture of about 5% of each of the other possible states with the S state.

If one assumes that tritium contains about 5% ^2P state, 5% ^4P state and 5% ^4D state, then one would draw the same conclusion for He^3 and it would be anticipated that the magnitude of the moment of He^3 would be about 7% greater than the numerical value of the neutron moment.

MDDC - 626 **Berkeley Isotope Chart, by R. Segre**

Revised September 1946 from MDDC-184.

MDDC - 627 **Sid Magnet Model Test Results by D. C. Sewell.**

A series of calibration curves for the magnet of the 184'' cyclotron have been plotted.

MDDC 628

Synthesis of Carbon Radioactive Methyl Iodide and Methanol from Carbon Dioxide by B. M. Tolbert. 6 p. (See also Journal of the American Chemical Society Vol. 69 p. 1529-1531 June 1947)

Carbon radioactive methyl iodide and methanol are of considerable importance in the synthetic chemistry of radioactive compounds for the introduction of labeled carbon. In this paper, a small scale (25 millimoles) and high yield (81-86% based on $C^{14}O_2$ taken) synthesis of these two compounds from carbon dioxide is presented.

The following reactions were used for the several steps:

1. $BaC^*O_3 \xrightarrow{H_2SO_4} C^*O_2$ (0.025 moles) — 100%

2. $C^*O_2 + 3H_2 \xrightarrow[KCuAl_2O_3 \text{ catalyst}]{460 \text{ atm. pressure}} C^*H_3OH + H_2O$ — 80-90%

3. $C^*H_3OH \xrightarrow[H_2O]{I_2 + \text{Red } P_4} C^*H_3I$ — 95-100%

Special techniques are necessary for the handling of small amounts of volatile organic compounds. Thus all reactions, washings and transfers were done in a closed system that had been evacuated to 10 microns or less pressure. Purification methods were chosen that could be adapted to vacuum line work. Liquid nitrogen was used to freeze contents of reaction vessels and traps during evacuation. Quantitative transfers were effected by distilling compounds from one vessel to another using liquid nitrogen. The vacuum line used for this work was developed for general organic synthesis and has proved very satisfactory in service. Reaction tubes and vessels may be closed off, removed from the line, and as needed, heated, refluxed or shaken. The connecting lines are re-evacuated when the vessels are returned to the system.

MDDC - 629 Diffraction of Neutrons by a Single Crystal, by W. H. Zinn. 15 p. (See also Physical Review Vol. 71, p.752-757, June 1, 1947)

The intensity of neutrons emitted by the nuclear chain reactor has been shown to be sufficiently intense to permit the Bragg reflection of neutrons by a single crystal. A single crystal monochromator has been constructed and has been used for the investigation of resonances. The well-known resonance in Cd has been measured and the Breit-Wigner constants determined.

MDDC - 630 Absorption and Scattering of Beta Particles and Application to Determination of Disintegration Rates of Radioactive Sources, by N. E. Ballou, et al. 1 p.

From the expression for the energy distribution of beta particles given by the Fermi theory of beta disintegration, distribution curves were calculated for spectra of 0.5, 1, 2, and 3 Mev maximum energy. An absorption curve for a beta spectrum was predicted by a graphical method with the assumption that a monoenergetic electron beam is absorbed linearly. Determination of the beta range from this curve by the empirical Feather method gave good agreement with the maximum energy assumed.

Experimentally determined aluminum absorption curves deviate from the predicted absorption curve. This due to the position and mounting of the source and the position of the absorbers. Interpretations of these deviations are advanced on the basis of scattering of the primary beta radiations.

From the investigations data on scattering, corrections were obtained which allowed accurate calculation of source disintegration rates. This was applied to procedures for the preparation of weightless RaE and UX_2 beta geometry standards. The RaE calibration was made by measuring the growth of RaF alpha activity into a pure RaE source. The UX_2 calibration was made by calculation of the UX_2 activity in uranium and separation of the UX_1 plus UX_2 activity with a small amount of carrier LaF_3 from a known amount of uranium. The two standards give results which agree within a few percent.

This report is an abstract only and the full text is reproduced here.

MDDC - 631 **A Comparison of the Sum of the Individual Fission Product Activities with the Gross Activity of Neutron Irradiated Uranium, by N. E. Ballou, et al 1 p.**

The comparison of the sum of the individual fission product activities with the gross activity of the uranium from which they were separated chemically is an essential check on the completeness of the knowledge of the fission products. Such a detailed study was made twice during the course of the Plutonium Project, the emphasis being on long-lived fission products. For example, in the second study, started 118 days after the end of an 11 day neutron irradiation of the uranium, the comparison was followed for about 600 days. The beta activity of the uranium could be accounted for to within better than 2 percent. The gamma comparison showed the summation to be 3-9 percent low for intermediate periods of decay. Although this may indicate an as yet unknown gamma emitter, it is probable that some of the discrepancy may be due to the larger uncertainties in gamma counting.

This report is an abstract for oral presentation and is presented in its entirety.

MDDC - 632 **Radiochemistry of the La, Ce, and Pr Fission Products, by N.E. Ballou, W.H. Burgus, R.R. Edwards, H. Gest, R. Hein, A. Kant, and A.S. Newton. 1 p.**

The fission product activities belonging to the rare earth elements were separated from other fission products by precipitating, with carrier, the acid insoluble rare earth fluorides. The chemical characterizations of the first members of the rare earths were based on:

1. **the oxidizability of cerium and insolubility of ceric iodate**
2. **the insolubility of the lanthanum subgroup (La, Pr, Nd, 61, Sm, Eu) carbonates in a K_2CO_3 solution.**
3. **the rough separation of La from Pr and Nd by fusing them with $NaNO_3$ and extracting the major part of the La from the resulting melt with buffered acetic acid.**

Among the elements La, Ce, and Pr, the following radioactive chains and single activities are known to occur in U fission:

40.0h La^{140}
3.7h La^{141} → 28d Ce^{141},
74m $La^{(142)}$,
19m La^{143} → 33h Ce^{143} → 13.8d Pr^{143},
275d Ce^{144} → 17.5m $Pr^{(144)}$,
1.8h $Ce^{(145)}$ → 4.5h $Pr^{(145)}$,
14.6m $Ce^{(146)}$ → 24.6m $Pr^{(146)}$.

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MDDC - 632

Radiochemistry of the La, Ce, and Pr Fission Products, by N. E. Ballou, W. H. Burgus, R. R. Edwards, H. Gest, R. Hein, A. Kant, and A. S. Newton. 1 p.
(Cont'd from page 404)

Of these, the underlined were discovered in the work of the Manhattan Project. In addition, the 19m La was shown to be the precursor of 33h Ce and 13.8d Pr; the 17.5m Pr was shown to be the daughter of 275d Ce; and 1.8h Ce was found to be the parent of 4.5h Pr. Mass assignments of the two activities, 33h Ce and 28d Ce, were made by comparing relative yields from slow and fast neutron radiation of Ce.

This report is an abstract for oral presentation and is reproduced in its entirety.

MDDC - 633

Survey of Ruthenium and Rhodium Isotopes formed in the Fission Process, by N. E. Ballou. 1 p.

This is an abstract only and the complete text has been reproduced here.

Radioactive isotopes of ruthenium of masses 103, 105, 106 and possibly 107 have been identified. Each of these decays to a relatively short-lived rhodium activity including the excited state of Rh^{103}. In addition an unassigned Rh activity of 9-hr half-life has been found. The masses of these fission chains are such as to place them on the descending arm of the fission yield curve for the light group. Two of the ruthenium activities have relatively long half-lives, they are formed in good yield and constitute the best source of tracer for this element. These are the 42-day Ru^{103} and the 1.0 year Ru^{106}. Although the radiation of Ru^{106} is difficult to detect, the hard beta-rays of its Rh^{106} daughter allow it to be readily measured.

The radioactive species known are:

(Cont'd on next page)

MDDC - 633 Survey of Ruthenium and Rhodium Isotopes formed in the Fission Process, by N. E. Ballou. 1 p. (Cont'd from page 405)

Isotope	Half-lives	β-energy (Mev)	γ energy (Mev)	fission yield
Ru^{103}	42 days	0.2	0.56	3.7
Ru^{105}	4.5 hours	1.35	0.76	~0.9
Ru^{106}	1.0 years	very soft	no γ	0.5
$Ru^{(107?)}$	4 min	~4		
Rh^{103*}	56 min	0.03 (e)	x-ray	
Rh^{105}	36.5 hr	0.60	0.33	
Rh^{106}	30 sec	~2.8,3.9	0.3,0.8	
$Rh^{(107?)}$	24 min	1.2		
Rh	9 hr	1.3	0.8	

MDDC - 634 Radioisotope Tracer Techniques, by G. E. Boyd. 1 p., n.d., decl. 2/7/47.

This document is an abstract and is presented here in full.

The application of radioactive isotope tracer techniques to many research problems in the chemical sciences has become generally possible owing to the recent greatly improved availability of radioactive materials produced by the uranium chain reactor. The radioisotopes C^{14}, H^3, S^{35}, p^{32} and the radiohalogens are likely to find the most immediate, and ultimately, widespread use. The half-lives, the mode and energy of disintegration, possible methods of production, and the specific activity obtainable for these isotopes are reviewed briefly.

General methods for the labelling of compounds with radioactive atoms will be outlined and exemplified by the small scale synthesis of radiocarbon, sulfur and bromine into typical organic compounds. Two basic types of commercially procurable bench-top instrumentation for the routine assay of beta and gamma radioactivity will be described together with a few procedures for the measurement of solid, liquid, and gaseous samples.

A short discussion of the factors involved in the use of radioisotopes as tracers and illustrations of some of the types of applications of labelled compounds to problems which may be investigated in the laboratory are presented.

MDDC - 634 is an abstract of a paper which was presented orally and issued partially (without illustrations) as MDDC - 840.

MDDC - 635 **The Development and Use of A 600-Ampere Fluorine Cell by W. B. Burford III. 24 p. (See also Industrial and Engineering Chemistry Vol. 39, p. 266-272, March, 1947).**

This cell operated at about 275° with an electrolyte of approximate composition KHF_2. Diphenyl oxide was used as a thermostatic liquid. The anodes were made of grade K-1 carbon (Stackpole Carbon Co,) and lasted about 300 hours. During operation the cell was swept with HF. The anode c.d. was 300-325 amp./ sq.ft. The potential drop was 6-8 v. With aging of the anode assembly, the current efficiency fell from 95% to 55%. The cell, constructed of monel, weighed about 400 lb. and occupied 2 x 4 ft. of floor space. It delivered about 0.75 lb. F per hour.

MDDC - 636 **Experimental Investigation of Threshold Pressure for Stable Operation of Arcs, by E. H. S. Burhop, H. S. W. Massey, G. Page. 27 p.**

Some experiments are described which are directed towards testing the theory which ascribes the pressure limitation on stable arc operation to the need for a sufficient supply of ions to the filament to satisfy the Langmuir condition at the double sheath there. The arcs were run in argon, helium and sulphur hexafluoride and good general agreement with the theory was found in all three cases.

MDDC - 637 **Attempted Preparation of a Volatile Uranium Carbonyl, by G. Calingaert, et. al. 17 p. May 29, 1946.**

Attempts were made to prepare a volatile carbonyl of uranium by a number of methods. These included direct reaction of carbon monoxide with uranium metal and uranium hydride; reaction of uranium hydride with nickel carbonyl; reaction of carbon monoxide with uranium halides in the presence of potassium cyanide, cystine, and reducing agents such as the Grignard reagent, zinc alkyls, butyllithium, zinc, and sodium; and reaction of carbon monoxide with uranium pentaethylate and uranium borohydride. In no instance was there obtained any evidence of the formation of a uranium carbonyl.

MDDC - 638 **The Preparation of Fission Radioisotopes for Radiotoxicological Studies, by W. E. Cohn 1 p.**

This paper is an abstract only. The large-scale production of fission for the purpose of creating plutonium poses new problems in health protection because of the unprecedented amounts of new elements which are formed. Many of these are created as pure radioelements and have physical and chemical properties which make them an extreme radiotoxicological hazard. In order to estimate the degree of protection required from these materials, biological experiments- from tracer to toxic levels of activity - were carried out with the purified radio-elements.

The chemical requirements placed upon the radioactive preparations used were very stringent. The dependence of radiotoxicity (toxicity due to radiation rather than to chemical nature of the element) upon energies and half-lives made the use of the fission radioisotopes themselves mandatory and severely limited the permissible extent of cross-contamination of one radioelement with another. Radiochemical separation procedures capable of separating quantitatively, by remote control, free of extraneous solid matter, and in the carrier-free state such similar elements as Ba and Sr, Ce and Y, etc., were required.

The separation of most of the desired fission products in the requisite purity has been accomplished by a process of selective elution of each element from an ion-exchanging resin. In certain special cases, coprecipitation or volatilization procedures were useful (e.g., for Sr and I, respectively).

MDDC - 639 **Boron Absorption of Resonance Activation, by S. M. Dancoff, 2 p.**

The absorption of neutrons with energy above Cd cut-off by the following nuclei has been studied: Na^{23}, Al^{27}, Cl^{37}, V^{51}, Mn^{55}, Cu^{65}, Cb^{93}. A beam of fast neutrons from the heavy water pile, whose flux had a (dE/E) spectrum, was permitted to fall on the target, and the activation measured. The beam was then filtered through increasing thicknesses of boron absorbers enriched in B^{10}. The resulting variation of activation with absorber thickness was analyzed. It was found possible in each case to separate the activation into:

(a) a component due to a $\left(\frac{1}{v}\right)$ cross section, and

(b) at least one component due to a discrete energy group, or resonance.

By appropriate calibrations of the targets it is also possible to obtain the activation integral, $\int \sigma \, dE/E$, associated with (a) and with (b). A summary of the energies and activation integrals follows:

Target	Res. Energy (ev)	$\int \frac{\sigma \, dE}{E}$ (a) + (b) ($\times 10^{24}$ cm^2)	$\int \frac{\sigma \, dE}{E}$ (b) only ($\times 10^{24}$ cm^2)
Na^{23}	1710	.265	.0510
Al^{27}	9100	.143	.0195
Cl^{37}	1800	.0866	.00635
V^{51}	3370	3.04	.358
Mn^{55}	261	14.31	8.16
Cu^{65}	570	.621	.299
Cb^{93}	Uncertain	.0349	.0296

MDDC - 640 Properties of Br at Tracer Concentrations, by R. R. Edwards, T. H. Davies. 20 p.

The reactivity of tracer Br in CCl_4 solution has been studied. The solutions were prepared by CCl_4 extraction of Br^{82} from $KMnO_4$ solutions of neutron-irradiated $KBrO_3$. Bromine concentrations were estimated as less than 10^{-10}M. The Br in CCl_4 undergoes a change such that a large fraction is extractable by water after a few minutes. Some is bound by the solvent, and an approximately equal quantity is lost perhaps to the walls. About 14 ± 4 per cent of the initial activity is present in a form which does not extract with water or exchange with Br^- in water, which reacts rapidly in the dark with CH_3CHBr_2 and which is extractable by HSO_3^- - Br^- solution.

The experiments are discussed in the light of the hypothesis that this latter form is stablized "atomic" Br, which persists for long periods of time in purified CCl_4. The binding of Br by the solvent is regarded as the result of reaction with solvent molecules disrupted or ionized by the β radiation of Br^{82}.

MDDC - 641 Radiochemical Beta Radiation Measurements, by N. Elliott, D. W. Engelkemeir, W. Rubinson, and E. Shapiro. 1 p.

This document is an abstract.

Experimental measurements of the intensity of beta radiation have been made with the type of apparatus commonly used in radiochemistry.

The angular distribution of beta rays emerging from a plane source of finite dimensions was found to be a function of the thickness of the sample. The radiation is nearly isotropic for sources of negligible weight, but obeys the law, $I = A + B \cos\theta$ for sources of appreciable thickness, where I is the intensity of radiation, θ is the angle between the normal direction to the plane source and the direction in which I is measured, and A and B are constants.

The effect of absorbers and reflectors on the measured beta radiation has also been considered. The experimental arrangement generally used in radiochemistry is easily described in a system of cylindrical coordinates. From the analysis the interesting result was obtained that the measured intensity of beta is a sensitive function of the thickness of the emitting source and absorbers, and of the relative positions of these with respect to the counter.

MDDC 642 **Biologic Effects of Long-Continued Whole Body Irradiation with Gamma Rays on Mice, Guinea Pigs, and Rabbits, by A. B. Eschenbrenner. 44 p.**

Histologic observations in animals exposed to long continued irradiation with γ rays were the following. Mice:-The lymphoid tissue was only affected in the 2.2 r, 4.4 r, and 8.8 r levels but changes observed initially did not progress with increasing total dose. Malignant lymphoma (leukemia), which was associated in only a small number of cases with a lymphomatosis in the circulating blood, involved all lymphoid tissues frequently with local invasiveness and metastases to many organs. The interstitial tissue of the testes appeared unaffected for the highest accumulated doses (approx. 5000 r). Damage to the testes was restricted to the tubules and the various spermatogenic elements, but even at the highest total doses occasional spermatogonia or spermatocytes, but no spermatozoa, were found. Damage to testes is dependent upon dose rate rather than total dose. Damage to the ovaries is dependent upon total dose and is irreversible. It consists of diminution in the number of follicles and final disappearance of these structures followed by tubular downgrowth of the germinal epithelium, and finally the development of several types of ovarian tumors. In a few cases a sarcoma at the site of the mammary gland was associated with the ovarian tumors.

Guinea pigs: -The most important changes were observed in the blood forming organs. All animals of the 8.8 r and most of the animals of the 4.4 r and 2.2 r levels died of anemia and thrombocytopenia. Bone marrow in these animals was aplastic to a varying degree. The testes were as radiosensitive as those of mice and showed a similar picture of damage. Ovaries were not affected and showed numerous developing follicles even for total doses as high as 4000 r. Lung tumors were observed in two animals that were exposed to total doses of 4000 r. These tumors were of alveolar origin.

MDDC - 643 Geochemistry of Beryllium, by M. Fleischer, E. N. Cameron. 27 p.

This is a review, with annotated bibliography, of the mode of occurrence of the element beryllium. It is not a list of specific ore deposits, but a summary of the types of minerals and rocks in which beryllium has been reported to occur. In addition, the unpublished spectrographic studies of the Geological Survey on mill products are summarized, and data are given on domestic production and reserves and on foreign production.

Beryllium is now obtained solely from beryl, mined from granitic pegmatites. Other beryllium minerals, all confined to granitic and syenitic pegmatites, are not likely to be commercial sources, but contact metamorphic deposits of helvite of commercial grade might possibly be found. Suggestions are made for further investigations, particularly of methods of concentrating lowgrade beryl ores, and of the occurrence of beryllium in American coals.

MDDC - 644 The Geochemistry of Columbium and Tantalum, by J. O. Harder, M. Fleischer. 28 p.

This is a review, with annotated bibliography, of the mode of occurrence of the elements columbium and tantalum. It is not a list of specific ore deposits, but a summary of the types of minerals and rocks in which these elements have been reported to occur. In addition, the unpublished spectrographic studies of the Geological Survey are summarized, best sources for columbium and tantalum are indicated, and suggestions are made for further investigation.

Columbium and tantalum occur most abundantly in certain minerals which form late in the general process of magmatic differentiation, including the late hydrothermal stages. These minerals occur almost without exception in granitic and syenitic pegmatites and placers derived therefrom. Among the metallic elements, columbium and tantalum are most closely associated with titanium and zirconium, and to some extent with tungsten and tin, as might be expected from their ionic radii. The Cb_2O_5 + Ta_2O_5 content of the minerals varies from a trace to 86 percent. The high value is for columbite-tantalite, the most common ore mineral of columbium and tantalum.

The domestic reserves of columbium-tantalum minerals are estimated to be 875,800 pounds of all minerals as of January 1, 1945. No grade figures are reported. Products of tin smelters and plants which treat minerals chemically for elements such as titanium and tungsten should be investigated for columbium of the basis of association.

MDDC - 645 Geochemistry of Germanium, by M. Fleischer, J. O. Harder. 27 p.

This is a review, with annotated bibliography, of the mode of occurrence of the element germanium. It is not a list of specific ore deposits, but a summary of the types of minerals and rocks in which germanium has been reported to occur. Best sources for germanium are indicated, based on the data in the literature and on the unpublished spectrographic studies of the Geological Survey on mill and smelter products. Suggestions are made for further investigations.

Germanium occurs most abundantly in sphalerites of low temperature deposits. The amount ranges from traces to tenths of a percent. Cinnabar sometimes contains germanium in tenths of a percent and enargites contain up to 0.1 percent. Pyrargyrite contains up to 1.0 percent and some tin-bearing sulfides have 0.5 percent germanium. Many other minerals have germanium in hundredths of a percent.

Some residues in zinc smelting contain more than 1.0 percent germanium. Dusts and ashes from the burning of certain coals contain germanium in amounts from tenths to more than 1.0 percent. Zinc smelter residues are believed to offer the best immediate chance for recovery of germanium, but copper smelters, and plants burning large quantities of coal should be investigated.

MDDC - 646 The Geochemistry of Indium, by M. Fleischer, J. O. Harder. 25 p.

This is a review, with annotated bibliography, of the mode of occurrence of the element indium. It is not a list of specific ore deposits, but a summary of the types of minerals and rocks in which indium has been reported to occur. In addition, the unpublished spectrographic studies of the Geological Survey on mill and smelter products are summarized, best sources of indium are indicated, and suggestions are made for further investigations.

Indium has been found to occur most abundantly in the sphalerites. The amount ranges from traces to a maximum of 1.0 percent. Dark sphalerites are reported richer in indium than light-colored sphalerites. Up to 0.1 percent indium has been reported in chalcopyrite and bornite, but these minerals generally contain very little indium. Some sulfo-salts of tin from Bolivia contain up to 1.0 percent indium. There is an unverified report of a pegmatite in Utah containing 1.0 to 2.8 percent indium.

Some residues in zinc smelting contain more than 1.0 percent indium and are the present source of indium. No better source can be suggested but steps should be taken to ascertain that this source is being fully exploited. Tin sulfide smelter products should be checked. An effort should be made to check the Utah pegmatite occurrence.

MDDC - 647 **Some Studies of the Reactions of Uranium Oxides with Hydrogen, Oxygen and Water, by D. M. Gillies. 69 p.**

The purpose of this research was to obtain data that would be useful in predicting changes that might be expected to occur in the oxidation state and degree of hydration of powdered uranium oxides maintained for long long periods of time at temperatures between 30 and 300°C. in the presence of excess water, hydrogen, oxygen and possibly hydrogen peroxide.

The reaction of hydrogen and oxygen with water slurries of U_3O_8 were studied at 100-300°C. The rates of these reactions appear to fit an equation of the form $\frac{-d(1-x)}{dt} = kp^n (1-x)^\theta$, where x is the fraction of the U^{+6} or U^{+4} which has been reduced or oxidized, respectively, at time t, and n is the order of the reaction with respect to the pressure, p, of the reacting gas. The exponent θ, the "order" of the reaction with respect to the solid oxide, is thought of as a measure of the decrease of the solid surface with time, the difficulty encountered by the gas molecules in penetrating the solid particles, or some equivalent phenomenon.

The oxidation reaction appears to be first order with respect to oxygen (experimentally n = 1.14), and the value of θ, for the particular oxide preparation used, was 3.7. The activation energy was computed to be 13,000 cal. ± 10%

The value of θ for the reduction reaction, using the same oxide, was 15.0. Assuming the reaction to be first order with respect to hydrogen, the activation energy is 10.000 cal. ± 15%.

U_3O_8 suspended in liquid water is oxidized much more rapidly than it is reduced. Under 14 atmospheres of oxygen the oxidation reaction is 76% complete in 2 hours at 250°C.; under 16.5 atmospheres of hydrogen the reduction reaction is only 5-6% complete in 2 hours at 250°C. This difference in rate is due largely to the difference in θ for the two reactions, that is the rate of the reduction reaction decreases more rapidly with decrease in "available oxide surface" than does the rate of the oxidation reaction.

$UO_3.H_2O$ was reduced even more slowly than U_3O_8, possibly because the crystal size was much greater.

The results indicate that in a uranium oxide - water mixture exposed to hydrogen and oxygen at pressures of similar magnitude the uranium would drift toward the hexavalent state.

The thermal decompositon of $UO_4.2H_2O$ in the presence of liquid water, giving hydrated UO_3 and oxygen, was studied as a function of temperature. At 61°C. the reaction is detectable but very slow; at 100°C. the half life is about 400 hours; at 185°C. the reaction is essentially complete in 1 hour.

Assuming either a first or second order process, the activation energy is 30,000 cal.. ± 10%.

(Cont'd on next page)

MDDC - 647 **Some Studies of the Reactions of Uranium Oxides with Hydrogen, Oxygen and Water by D. M. Gillies. 69 p. (Cont'd from page 414)**

The thermal stability of the hydrates of UO_3 in the presence of liquid water was investigated. The highest hydrate, $UO_3.2H_2O$, is stable up to at least 61°C. The transition to $UO_3.H_2O$ occurs between 61 and 77°C. At 265°C. the monohydrate seems to be stable, but at 300°C. it slowly loses water. At 350°C. a crystalline hemihydrate, $UO_3.\frac{1}{2}H_2O$, is formed.

Previously unreported polymorphic forms of the hydrates exist. Different forms were obtained by the reaction of two different forms of the anydrous oxide with water.

Two forms of the dihydrate were found; both were microcrystalline, but the X-ray patterns of the two were distinct.

At least two forms of the monohydrate exist, a rhombic form and a triclinic form.

The hemihydrate is a definite crystalline compound. The crystal form is probably monoclinic.

The crystalline monohydrate reacts with water extremely slowly and can exist in liquid water for long periods at temperatures where the dihydrate is thought to be stable.

Evidence is presented to support the conclusion that in the dihydrate one mole of water is present as zeolitic water.

Anhydrous UO_2 and U_3O_8 were not found to react with water.

MDDC - 648 **The Metabolism of Thorium, Protoactinium, and Neptunium in the Rat, by H. Lanz, K. G. Scott, J. Growley, J. G. Hamilton. 18 p.**

The distribution of carrier-free thorium, protoactiniun and neptunium in the rat following intramuscular and oral administration has been studied. Oral absorption for all three is negligible. Following parenteral administration, the skeleton is the organ showing the highest degree of prolonged and selective localization.

MDDC - 649 **Measurement of C^{14} Activity, by W. B. Leslie and C. J. Borkowski. 1 p.**

This paper is an abstract;

The measurement of C^{14} activity in solid samples, usually $BaCO_3$, has certain limitations because of large absorption of β particles emitted by the sample itself (up to 80% for samples of mass 20 mg./sq. cm.) and absorption by the window of the counter. Geometry factors further reduce the number of particles entering the counter.

A procedure is under development for the conversion of organic materials (or $BaCO_3$) to carbon dioxide, which is subsequently introduced into a suitable ionization chamber. The ion current produced by the emitted C^{14} β particles is measured with a dynamic condenser electrometer, which is capable of measuring currents of the order of 10^{-16} ampere or higher.

MDDC -650 Synthesis of Organic Compounds from $C^{14}O_2$, by W. B. Leslie, and L. B. Spector. 1 p.

This paper is an abstract.

Acetic and isovaleric acid have been prepared from $C^{14}O_2$ by the following sequence of reactions:

$$RX + Mg \rightarrow RMgX$$

$$RMgX + C^{14}O_2 \rightarrow RC^{14}OOMgX$$

$$RC^{14}COOMgX + H_2O \rightarrow RC^{14}COOH + MgXOH$$

Carbon dioxide was generated from $BaC^{14}O_3$ by addition of acid, and passed into a vessel containing the Grignard reagent. After a brief vigorous shaking, water is introduced to destroy the excess of reagent.

The acetic acid was isolated by steam distillation, followed by neutralization of the distillate and evaporation to dryness. After acidification, the acetic acid was concentrated by steam distillation, either extraction, and a final distillation. The overall yield, based on CO_2 was 70%. The specific activity of the 7.8 g. of acid obtained was 22.4 microcuries/gm.

The isovaleric acid, prepared on a much smaller scale (100 mg.), was isolated from the solution obtained upon hydrolysis of the Grignard reaction mixture by steam distillation. The distillate was evaporated to dryness, yielding 85% of the theoretical quantity of acid, based on the CO_2 employed. The specific activity of this acid was very nearly the same as that of the acetic acid.

MDDC - 651 Capture of Fast Neutrons by Pb^{208}, by J. S. Levinger. 15 p.

Comparison of the activity produced by fast neutrons on lead with other activations corroborates the assignment of the 3.2 hr. activity as Pb^{209}, and the assignment of the reaction as capture of fast neutrons. Two different measurements show that the neutrons captured have energies greater than 100 Kev. The average capture cross section for primary neutrons from 7.5 Mev deuterons on a thick target of beryllium is measured as 10^{-27} cm^2.

MDDC - 652 The n-Gamma Reaction for Fast Neutrons for Pb^{208}, Bi, and Al, by J. S. Levinger

A beta-ray spectrometer examination of the activity of 3.3 hr. lead corroborates the assignment to Pb^{209}. This activity, produced by n-gamma capture by Pb^{208}, occurs for fast neutrons with a cross section of about .003 barns. In the region above 1 Mev neutron energy, the cross section appears to decrease with increasing neutron energy. Bismuth shows activity probably due to fast neutron capture, with a cross section of about .005 barns. The aluminum n-gamma activity appears to be due to a resonance level somewhat higher than 25 e.v. The upper limit for the n-gamma cross section for fast neutrons can be set as .003 barns.

MDDC - 653

Biologic Effects of Long-Continued Whole Body Irradiation With Gamma Rays on Mice, Guinea Pigs and Rabbits, Part I. by Egon Lorenz and Walter E. Heston. 15 p.

Male and female mice of the C3H strain were continuously irradiated with 4.4 r, 1.1 r, 0.11 r and 0.044 r per day. No significant damage to the hematopoietic system as evidenced by blood counts was found although the highest total dose was over 2000 r. Mammary tumor incidence was not changed significantly in the animals exposed on the different dose levels. Histologically only the gonad showed radiation damage and mainly in the animals exposed to 4.4 r per day. The damage consisted in the testes in diminished spermatogenesis and was reversible. Irradiation damage to the ovaries was irreversible and progressive and resulted in some cases in tubular downgrowths of the germinal epithelium which progressed to early tumor formation. Breeding experiments indicated that C3H females were permanently sterilized with total doses of 465 r given at the rate of 4.4 r per day. Subsequent generations reared and maintained in exposure fields of 1.1 r and 0.11 per day showed no damage to chromosomes as evidenced by raising of 5 to 6 generations with normal litter size and apparently normal life span.

MDDC - 654

Biologic Effects of Long-Continued Whole Body Irradiation With Gamma Rays on Mice, Guinea Pigs, and Rabbits, Part II, by E. Lorenz. 14 p.

Experimental arrangements are described for the simultaneous irradiation of considerable numbers of animals with γ rays. Three experimental setups were available. In the first a source of approximately 1 g of radium element was used, with 4 sets of shelves forming part of a sphere surrounding the source. Daily doses at the different shelves were 8.8 r, 4.4 r, 2.2 r and 1.1 r in 8 hours. In the second setup a source of 1000 mg radium element in a lead box with a hinged lid was employed to irradiate one set of shelves. The daily dose at this set of shelves was 0.11 r in 8 hours. In the third setup a source of 250 mg element, also housed in a lead box, was used with 6 sets of shelves. Here the exposure was continuous, the daily doses amounting to 8.8r, 4.4 r, 2.2 r, 1.1 r, 0.55 r, and 0.11 r in 24 hours. Dose measurements with calibrated 0.25 r, Victoreen ionization chambers, were made in every one of the animal cages which were placed on the different shelves. Errors are discussed which arise mainly from the dimensions of the cages. They are for mouse and guinea pig cages approximately $\pm$ 15 per cent, and for rabbit cages $\pm$ 25 per cent. The precautions taken to reduce the residual dose to a minimum are described.

MDDC - 655 **Biologic Effects of Long-Continued Whole Body Irradiation with Gamma Rays on Mice, Guinea Pigs, and Rabbits, Part III, by E. Lorenz et al. 173 p.**

Studies concerning the continuous gamma irradiation of mice (LAF hybrids), guinea pigs (hybrids,and inbred strains), and rabbits (hybrids) by means of the experimental arrangements described in Part II make possible the following conclusions. On all daily dose levels, including the 0.11 r level, there was a decrease in the life span of mice. The decrease in life span was pronounced in guinea pigs exposed to 8.8 r, 4.4 r, and 2.2 r per day. The life span of rabbits was decreased in the animals exposed to 8.8 r and 4.4 r. Data on the life span of guinea pigs and rabbits exposed on the lower levels are not conclusive as yet since some of the animals are still alive. An increase in weight was found in irradiated animals on the lower exposure levels mounting, in male mice exposed to 1.1 r, to 50 per cent of that of the control animals. The hemopoietic system of rabbits is entremely radio resistant, and changes in the blood picture were found only in the animals exposed to 8.8 r per day. The hemopoietic system of mice is also radioresistant; the main effect of irradiation consisting in a depression of the lymphocyte count. No damage to bone marrow was observed (maximum accumulated dose 5800r). The hemopoietic system of guinea pigs is very radiosensitive. Anemia and thrombocytopenia,were observed in all animals exposed to 8.8 r and in most animals exposed to 4.4 r and 2.2 r per day. Bone marrow damage of moderate to severe degree was associated with the anemia. The carcinogenic action of irradiation was mainly observed in mice, but some irradiated guinea pigs and rabbits also developed tumors after three years of irradiation. Of special interest were lung tumors of alveolar origin found in two guinea pigs. The most important tumors observed in the mice were; malignant lymphoma (leukemia), lung tumors, ovarian tumors, and tumors of the mammary gland. The induction of malignant lymphoma was roughly dependent upon dose rate and total dose. The greater the dose rate, the earlier the tumors appeared. The genesis of ovarian tumors was different from that of malignant lymphoma and lung tumors. The ovarian tumors were the end product of an irreversible degenerative process in the ovary caused by irradiation and their development started with a depletion of follicles. Ovarian tumors were rare in control animals but their incidence was increased considerably on the 0.11 r level. Associated with the ovarian tumors, in some cases were sarcomas of the mammary gland. Ovaries of guinea pigs and rabbits were radioresistant. Irradiation injury to testes of mice and guinea pigs was dependent on dose rate and was reversible. Damage to testes was also dependent upon intensity. Testes of mice irradiated six days per week with 8.8 r of X-rays in 1.5 minutes showed considerably greater damage than testes of mice irradiated daily with 8.8 r of gamma rays given in 8 hours (total doses 300 r or 600 r respectively.)

MDDC - 656 **Biologic Effects of Long-continued Whole Body Irradiation with Gamma Rays on Mice, Guinea Pigs, and Rabbits, by E. Lorenz. Part VI. Conclusions and Applicability of Results to the Problem of Human Protection. 22p. December 11, 1946.**

Irradiation of organs and tissues, however small the dose given, will always result primarily in cell death or cell damage. This primary reaction may be followed by complex secondary reactions. Although little is known about secondary reactions, they may be caused by decomposition products of dead or damaged cells. They may occasionally simulate a stimulating effect. Although such effects have been observed, they are transient, and the reason for their existence is obscure. Emphasis is placed on the fact that the destructive action of radiation will invariably become evident if the experiments are carried out for a long enough period of time.

(1) The permissible dose for whole body exposure for 8 hours per day of 0.1 r can be maintained in men provided small, additional, acute exposures are not frequently given.

(2) The permissible dose for whole-body exposure to women for 8 hours per day can be 0.1 r, if working time is restricted to a few years. No additional acute exposures should be given. It might be advisable to lower the permissible dose for women to 0.02 r per 8 hours per day for working periods extending over many years.

(3) Exposure of hands only, with the rest of the body shielded so that whole-body exposure is limited to 0.1 r per 8 hours per day, may possibly be increased to 1 r per 8 hours per day.

(4) Until proven otherwise, a daily whole-body exposure to 0.1 r given in a very short time is not identical in its biologic effects to a daily 8 hour exposure to 0.1 r.

MDDC - 657 Thermodynamic Properties of Uranium Compounds by George E. MacWood. 77 p.

This paper presents all of the results that were obtained on heats of formation and equilibrium measurements of a number of uranium compounds. These data were combined into a self-consistent system of thermodynamic relationships for these substances.

Uranium compounds discussed are: UCl_3, UCl_4, UCl_5, $UCl_{5.85}$, UBr_3, UBr_4, UCl_3Br, UCl_2Br_2, $UClBr_3$, uranous oxychloride (81.1% $UOCl_2$ + 18.9% UO_2), uranous oxybromide (95.5% $UOBr_2$ + 4.5 UO_2) uranium dichloromonobromide (87% UCl_2Br + 13% UCl_3), uranium monochlorodibromide (70% $UClBr_2$ + 30% UBr_3), UI_3, UI_4, UCl_3I, UBr_3I.

The free energy relationships that were derived are summarized. The general formation of the equation employed is:
$\Delta F^o = \Delta H_o + a\,T \log T + b\,T^2 + IT$, in which ΔF^o is the free energy, ΔH_o, a, b, and I are constants, and T is the temperature, in degrees Kelvin.

MDDC - 658 Electrolytic Reduction of Uranyl Ion, by A. R. Nichols, Jr. 14 p.

Due to the hydrogen overvoltage at the surface of a mercury cathode, uranium solutions in hydrochloric acid may be reduced not only to the tetravalent state, but until considerable trivalent uranium is formed. Other metallic ions act as oxidation-reduction catalysts as well as being reduced themselves. This paper is a study of the various reactions taking place in solution and at the surface of the cathode.

Four different cells, referred to as the multiple cell, the unit cell, the batch cell, and the pilot cell were used in the course of this work. In each case a pool of mercury served as cathode. The anodes were of graphite.

The course of electrolytic reduction of uranyl chloride was studied in the presence of iron, copper, chromium, and nickel. Copper is first reduced to cuprous ion and then largely deposited in the mercury cathode. Chromium and copper are effective as reduction catalysis. Hydrogen is first evolved at a redox potential around +0.2 volts as measured between a tungsten probe and a silver-silver chloride half-cell. The reduction of uranium corresponds to a plateau in the redox potential curve in a range which is roughly + 0.05 to + 0.15 volts. Suspended copper appears at + 0.07 volts, corresponding to the disappearance of uranyl ion and the appearance of trivalent uranium. Practically no change in redox potential occurs after reaching a plateau at -0.55 volts.

MDDC - 659 Radioactivities Produced in Neutron Irradiation of Chloride, by R. T. Overman. 1 p.

This paper is an abstract only and the whole text is reproduced here.

Four activities produced in a very long neutron irradiation of various chlorine compounds in the Clinton Laboratories chain reacting pile were studied. Two activities in chlorine were confirmed and a new value for the half-life of Cl^{36} was determined assuming a beta particle per disintegration. A slightly different beta energy was found in the long-lived isotope. Chemical procedures for the separation of a sulfur activity and a phosphorous activity are described and a new value for the energy of the S^{35} beta particle are given.
These data are summarized in the following table:

Reaction	Half-life	Beta Energy (Mev)
$Cl^{35}(n, \gamma)\ Cl^{36}$	1 x 10^6 years	0.66
$Cl^{37}(n, \gamma)\ Cl^{38}$	37 minutes	complex
$Cl^{35}(n,p)\ S^{35}$	87 days	0.17
$Cl^{35}(n, \alpha)\ P^{32}$	14.7 days	1.7

MDDC - 660 Discharge Cathodes, by W. E. Parkins. 14 p.

Need for a simple, long life cathode suggested a search for different means of producing the electron stream required. New knowledge concerning gas discharge in electric and magnetic fields serving as guide led to the concept of a "discharge cathode". Here electrons produced in a Philips Ion Gauge (later denoted by PIG) type arc were transported by various schemes to where they could be used as the ionizing mechanism in the uranium arc. No such arrangement proved very satisfactory. However, the most successful discharge cathodes and some of their characteristics are described.

MDDC - 661 Techniques of External Irradiation with Beta Rays, by J. R. Raper, R. E. Zirkle, K. K. Barnes. 50 p.

Beta ray sources of high intensity have been developed for an extensive program of external irradiation of laboratory animals. Amorphous red phosphorus impregnated into phenolicformaldehyde resin, following activation in the Clinton Pile, was used as the source material.

The extrapolation chamber method of surface dose-rate determination was used as the primary standard for all beta ray measurements. Two specially designed chambers, 1 - surface chamber (2π) and 2 - pencil chamber (4π), as well as a number of standard ionizing radiation meters, were used for routine dosage rate measurements. Indirect determinations of beta ray dose by means of two biological dosimeters, fern spores and drosophila eggs, were in fair agreement with the physical measurements.

Depth dosage in an absorber of low atomic number (cellulose acetate) was measured for various types of sources of P^{32}, Y^{91}, and Sr^{89}. The half-layer thickness for beta rays of thick P^{32} source was 80 mg/cm^2, corresponding to 0.83 mm of soft tissue. The character of the radiation was strikingly affected by the following factors: 1) the particular emitter, 2) the type of source - thick or thin, and 3) in thin sources, the atomic number of the backing material. Depth dose curves in all cases were composed of 2 to 3 exponential segments.

Sources and techniques were developed to administer external beta ray exposures to various biological materials. The sources and techniques differed according to the special requirements of the material or animal to be irradiated: 1) acute total surface irradiation of mice, rats, guinea pigs, and rabbits; 2) daily low dose exposure of mice and rats, and 3) restricted area irradiation of rabbit and human skin.

MDDC - 662 New Observations on Two-Dimensional Condensation Phenomena, by S. Ross. 7 p.

This work describes the adsorption of ethane or specially prepared crystals of sodium chloride and potassium chloride at -183°C. Discontinuities in the adsorption isotherm are found to take place and can therefore be associated with the presence of either the (100) or (111) planes on the surface of sodium chloride and (100) planes on the surface of potassium chloride.

The gas adsorption apparatus using ethane was similar to that described by Wooten and Brown, (Journal of the American Chemical Society, 65, p. 113, 1943).

MDDC - 663 Infrared Spectrum of Benzene, by J. Flanagan, R. Gardner, F. McKee, R. Schlegel. 4 p.

Benzene shows weak absorption bands in the 3 aliphatic C-H region of the spectrum. The peaks of these bands are at 3.439, 3.459, 3.504, and 3.545.

MDDC - 664 The Lightest Elements Formed in Fission (Zn, Ga, Ge, As), by E. P. Steinberg, D. W. Engelkemeir, L. E. Glendenin, and J. M. Siegel. 1 p.

The discovery of Zn, Ga, Ge, and As isotopes in fission is discussed. This has extended the known range of fission products in the region of low mass number (the "light wing" of the fission yield vs. mass number curve) by 11 mass numbers and by a factor of 10^{-4} in fission yield beyond the 2.4h Br^{83} which was probably the lightest fission product known prior to the establishment of the Plutonium Project.

Data on the decay characteristics, energies, and fission yields of 49h Zn^{72}, 14.25h Ga^{72}, 5h $Ga^{(73)}$, 12h Ge^{77}, 2.1h $Ge^{(78)}$, 40h As^{77}, and 90m $As^{(78)}$ are presented and the mass assignments discussed. No longer-lived isotopes of these elements have been detected in fission.

Standard radiochemical techniques were employed in the isolation of these activities. The isolation of Zn involved precipitations of $ZnHg(SCN)_4$, followed by scavengings with Bi_2S_3, $Fe(OH)_3$, and $BaCO_3$, evaporations with HBr, and final precipitation as $ZnHg(SCN)_4$. For Ga, ether extractions from 6M HCl, precipitation of $Ga_4[Fe(CN)_6]_3$, scavengings as with Zn, evaporations with HBr, and final precipitation as the 8-hydroxyquinolate were used. Ge and As were isolated by precipitation of the sulfides, scavengings with $Zr(OH)_4$, distillation of the volatile chlorides and final precipitation as the sulfides. Decontamination factors of 10^9 in the cases of Zn and Ga and 10^6 in the cases of Ge and As were attained by repeated cycling of the sample through the steps of the procedures, thus ensuring products of high radiochemical purity.

The problem of extending the fission product range further (to Cu and Ni isotopes) is briefly treated.

This report is an abstract only and the full text is reproduced here.

MDDC - 665 **Accumulation of Uranium in the Tissues of Mice Ingesting Uranyl Nitrate, by A. Tannenbaum, H. Silverstone. 9 p.**

The previously observed fact (MDDC-615) that uranium gradually accumulates in the kidney and bones of mice that are daily fed a constant amount of an uranium compound was confirmed. The present experiment was not continued long enough to indicate, one way or the other, whether the uranium in the tissue finally reaches a plateau level (where absorption and excretion are approximately equal). The results of an earlier experiment suggest this possibility.

MDDC - 666 **Uptake of Plutonium, Yttrium, and Strontium by the Callus of Healing Bone Fractures, by L. Van Middlesworth, D. H. Copp, and J. G. Hamilton. 2 p.**

This paper is an abstract.

Plutonium, radioactive yttrium, and radioactive strontium are all metals of considerable practical importance which localize in the skeleton. Active uptake of Pu^{239} and Y^{88} in the callus of healing fibulae of adult male rats was observed on the second day, before calcification or strontium localization had commenced. Deposition of radioactive strontium in the callus began about the fourth or fifth day and reached a peak around eight to twelve days when calcification was most active.

MDDC - 667 **Samarium and Europium Isotopes Formed in Fission, by L. Winsberg. 1 p.**

This paper is an abstract.

Europium activities are cleanly separated from the other rare earth fission isotopes by reducing Eu^{+3} to Eu^{+2} with Zn amalgam and then precipitating the trivalent rare earth hydroxides from soluble europous hydroxide.

Samarium fission isotopes are separated from other rare earth contaminants, except Eu, by extracting a dilute acid solution of the trivalent ions with Na amalgam according to the method of Marsh, Journal of the Chemical Society, 1942, p. 523. Sm(and Eu) are extracted from the amalgam with 6N HCl. The Eu activities are then removed by precipitating $Sm(OH)_3$ from $Eu(OH)_2$ solution.

The following activities have been found in fission: 47h Sm^{153}, 25m Sm^{155}, ~10h Sm^{156}, 2y Eu^{155}, 15.4d Eu^{156}, 15.4h Eu^{157}, and 60m $Eu^{(158)}$ and the energies of their radiation determined by absorption measurements. The mass assignments have been made on the basis of fission yield values or mass spectrographic measurements. Lewis and Hayden have found long-lived Sm^{151} in fission material by means of the mass spectrograph.

MDDC - 668 **The Crystal Structure of $Ba_3(PO_4)_2$ and $Sr_3(PO_4)_2$, by W. H. Zachariasen. 11 p.**

The compounds $Ba_3(PO_4)_2$ and $Sr_3(PO_4)_2$ are rhombohedral and isomorphous. The unit cell contains one molecule. The lattice dimensions and calculated densities are:

	a	α	ρ
$Ba_3(PO_4)_2$	7.696 $\pm$ .002A	$42^o35' \pm 2'$	5.25
$Sr_3(PO_4)_2$	7.280 $\pm$ .002	$43^o21' \pm 2'$	4.53

The space group is R3m and the atomic positions are:

1 Ba or Sr	in	(o o o)
2 Ba or 2 Sr	in $\pm$	(u_1 u_1 u_1)
2 P	in $\pm$	(u_2 u_2 u_2)
2 O	in $\pm$	(u_3 u_3 u_3)
6 O	in $\pm$	(x x z) (x z x) (z x x)

The parameter values are:

	u_1	u_2	u_3	x	z
Ba-compound	.208	.412	.337	.285	.742
Sr-compound	.208	.412	.333	.279	.753

MDDC - 669 **Method for Measuring Neutron-Absorption Cross Sections by the Effect of the Reactivity of a Chain-Reacting Pile, by H. L. Anderson et al. 13 p (See also Physical Review Vol 72 p. 16-23, July 1, 1947)**

In the first two chain-reacting piles which were constructed at the Metallurgical Project, neutrons were reproduced in a structure consisting of a lattice of uranium lumps embedded in a pile of graphite bricks. In this structure neutrons are reproduced in a cycle in which fast neutrons are slowed down to thermal energies by elastic collisions with carbon. Upon reaching thermal energies, the neutrons continue to diffuse without further loss in energy, on the average, until they are either absorbed in the pile or escape by leakage out of the pile. A fraction of the neutrons which are absorbed produce fission in uranium with the liberation of new fast neutrons. The average number of neutrons produced from one original neutron in such a cycle is called the reproduction factor "k". The value of k depends on the balance of neutron production, absorption and leakage.

When the pile is operated at sufficiently high intensity, the neutron production is predominantly that from neutron-induced fission and the contribution from spontaneous fission (α,n) reactions, (γ,n) reactions and cosmic rays becomes vanishingly small. The pile is said to be in the critical condition when the neutron intensity remains constant.

In this work the effect of the insertion of an absorber in the pile has been measured by observing the displacement of the control rod which was required to return the pile to the critical condition. It was found, however, that for a given change in reactivity, the displacement required, if measured in centimeters, was not always the same but depended on the position of the control rod in the pile. It was convenient to introduce a new unit of rod position such that displacements measured in the new units would always be proportional to k-1. In order to provide a precise definition of such a unit, use was made of the property of the pile that its period is proportional to 1/k-1 in the limit of long periods. Accordingly, the unit of rod position was given the name inhour (from "inverse hour", symbol; ih) with the significance that when the control rod is displaced from the critical position by 1 inhour, the pile will have a period of (very nearly) 1 hour.

The introduction of a neutron-absorbing substance into a pile reduces the value of k. To compensate for this loss of k, it is necessary to move the control rod out of the pile. The change in the critical position of the rod measured in inhours is a measure of the absorption of the substance.

MDDC - 670 Scattering of Protons by Deuterons by C. Bailey et al. 27 p. (See also Physical Review Vol. 72 p. 662-672 October 15, 1947)

Utilizing a scattering chamber based upon the successful design used by Herb, Kerst, Parkinson and Plain (HKPP) in the measurement of proton-proton scattering, experimental data on the scattering of protons by deuterons have been obtained. The incident protons were accelerated by the 3.5 Mev Wisconsin generator ("long tank") which was used by the Manhattan Project at Los Alamos, New Mexico. The geometry, current, and pressure measurements were checked by the comparison of measurements of proton-proton scattering at 2.1 Mev with the work of HKPP. Results on proton-deuteron scattering at 0.825, 1.51, 2.08, 2.53, 3.00 and 3.49 Mev were obtained. The absolute cross-sections per unit solid angle show the presence at all energies studied of higher-order waves than the spherically symmetrical S-wave. A minimum in the scattering is observed near 90° at the low energies: the minimum shifts to larger angles with increasing energy. The cross-sections at all angles decrease with increasing energy but the ratio of the cross-section at 150° to the minimum increases gradually from 2.3 at 1.51 Mev to 3.0 at 3.49 Mev. The present results at 825 Kev do not show the large anomaly found by Tuve, Heydenburg and Hafstad at 830 Kev.

MDDC - 671 Artifical Radioactive Isotopes or Polonium, Bismuth and Lead, by J. J. Howland, D. H. Templeton and I. Perlman, 6 p. (See also Physical Review Vol. 71 p. 552, April 15, 1947 for abridgement of this report)

The following new artificial radioactive isotopes were produced and identified to varying degrees of certainty:

Isotope	Assignment Classification**	Mode of Decay	Half-life
Po^{206}	A	K (~90%), α(~10%, 5.2 Mev)	9.5 d
Po^{207}	A	K (~100%), α(~0.01%, 5.1 Mev)	5.7 h
$Po^{208,209}$	B	α(5.14 Mev)	~4 y
Bi^{204}	A	K, e^-, γ	12 h
Bi^{208}?	B	K (?), β^- (?)	~ 10^4 y
Pb^{201}?	D	K, e^-, γ	~5 h
Bi^{206}	A	K, e^-, γ	6.4 d
Pb^{204}*	A	I.T., e^-, γ	68 m
Pb^{203}	A	K, e^-, γ	52 h

**This classification on certainty of assignment is taken from the "Table of Isotopes" of G. T. Seaborg (Rev. Mod. Phys. 16 1, (1944) in which the symbols have the following meanings: A = Mass number and element certain
B = Mass number probable, element certain.
D = Element certain

MDDC - 672 **Activities Induced by Pile Neutron Bombardment of Samarium by M. G. Inghram, R. J. Hayden and D. C. Hess, Jr., 3 p. (See also Physical Review Vol 71 p. 643, May 1, 1947)**

A sample of Sm_2O_3 was given a long neutron bombardment in the Hanford pile. By mass spectrographic analysis active masses were observed at mass numbers 145, 151, 152, 154, 155, 156, 161, 167, 169 and 176. The interpretation of these active masses is given in the table below. Brackets are placed about those results which are only probable.

Mass No.	Ion	Active Isotopes	Half-life
145	Sm^{145+}	Sm^{145}	>5 day (possibly 60 da.)
151	Sm^{151+}	Sm^{151}	(~20 years)
152	Eu^{152+}	Eu^{152}	(~5 years)
154	Eu^{154+}	Eu^{154}	(~5 years)
155	Eu^{155+}	Eu^{155}	2-3 years
156	Eu^{156+}	Eu^{156}	>15.4 da.
161	$Sm^{145}O^{+}$	Sm^{145}	5 day (possible 60 da.)
167	$Sm^{151}O^{+}$	Sm^{151}	(~20 years)
169	$Gd^{153}O^{+}$	Gd^{153}	>5 day
176	$Tb^{160}O^{+}$	Tb^{160}	72 da.

MDDC - 673 Neutron Cross Sections for Mercury Isotopes by M. G. Inghram, D. C. Hess and R. J. Hayden. 3 p. (See also Physical Review Vol. 71 p. 561-562, April 15, 1947)

One hundred twenty-five milligrams of α phase mercuric sulfide were submitted to long bombardment by neutrons in a graphite pile. To liberate the mercury the sample was placed in a closed system and heated while oxygen was flowing through the system. The free mercury obtained was collected at -40°C in a glass sample tube and then transferred to the sample system of a Nier type mass spectrometer. The isotopic composition of the bombarded sample was then compared with that of normal mercury. The data obtained is summarized in the following table.

Isotopic Composition of Neutron Irradiated Mercury

Mass No.	% Abundance Normal	%Abundance Bombarded	Net Change	Isotopic Cross Sections In 10^{-24} cm^2	Contribution to Total Section in 10^{-24}cm^2
196	0.155	0.120	-0.035±0.002	3100	4.8
197	< 0.001	< 0.001	---	---	- -
198	10.12	10.17	+0.05±0.05	---	- -
199	17.01	13.78	-3.23±0.07	2500	425
200	23.21	26.52	+3.31±0.03	< 60	< 15
201	13.15	13.11	-0.04±0.07	< 60	< 8
202	29.66	29.63	-0.03±0.15	< 60	< 18
203	< 0.001	trace	+ trace	---	- -
204	6.69	6.68	-0.01±0.03	< 60	< 4
205	<0.001	<0.001	---		

MDDC - 674

Experimental Use of C^{14}: (I) Investigation of Counting Methods Using G. M. Tubes; (II) Synthesis of Active Organic Compounds; (III) Analysis of Ammonium Nitrate Solutions from the Carbon Factory, by W. B. Leslie. 17 p.

Samples containing C^{14}, especially those of high specific activity, may be measured in a rapid and routine manner by means of G. M. tubes. Reproducible results may be obtained if certain precautions are taken in the preparation of samples.

A small scale synthesis of radioactive isovaleric acid from $C^{14}O_2$ has been carried out, yielding 84% of the theoretical quantity of acid. Larger scale syntheses of isovaleryl chloride and isobutylmethyl ketone have been carried out with inactive materials.

Studies on ammonium nitrate solutions from the carbon factory have revealed that these solutions contain significant quantities of methanol, formaldehyde, and formic acid, the latter being present in the largest quantity.

MDDC - 675

Spectral Emissivity and Total Emissivity of Beryllium Oxide, by R. L. Seifert. 32 p.

The normal spectral emissivity at $\lambda = 0.665\ \mu$ has been determined for three types of "hot-pressed" beryllia in the temperature range 1200°K to 1900°K. The hemispherical total emissivity has been determined for the same types of beryllia in the temperature range 1200°K to 2150°K.

MDDC - 676 Higher Angular Momenta and Long Range Interaction In Resonance Reaction by E. P. Wigner and L. Eisenbud. 22 p. (See also Physical Review Vol. 72 p. 29-41 July 1, 1947)

The results of two preceding articles (Physical Review 70, 15, 1946 and 70, 606, 1946) on the energy dependence of the reaction and scattering cross sections are generalized. As before, the configuration space is divided into two parts. In the internal region or reaction zone there is no restriction on the type of interaction between the particles. In the external region, on the other hand, the interaction takes place between the colliding or separating particles without changing their structure (wave function). The present article deals with a more general situation than the preceding ones, first by allowing for an interaction, although only of a restricted type, outside the reaction zone. The most common type of interaction which plays a role outside the reaction zone is the electrostatic interaction of the colliding or separating particles. In addition, the present article does not restrict the angular momentum of the articles to zero but permits the treatment of arbitrary angular momenta. Although the relations which are being derived are formally independent of the size of the reaction zone (inside of which there is no restriction on the type of interaction) the significance of these relations becomes blurred if the size of this region is chosen too large.

MDDC - 677 Metabolsim and Distribution of Inhaled Plutonium in Rats, by R. Abrams et al. 30 p.

Several different techniques were used to introduce tracer quantities of plutonium into the lungs of rats. When aerosols were produced by atomizing aqueous solutions of the nitrates it was found that approximately 20 per cent of the dose was absorbed and deposited in the skeleton with tetra-, hexa-, and trivalent plutonium. Thus with these compounds, the lungs represent a more dangerous portal of entry than either oral (0.05 per cent) or intramuscular (13 per cent) administration.

Tetravalent Pu was eliminated most slowly from the lung, the average half-time during the first month being 15 days. But when citrate was added to complex the Pu, over 70 per cent was eliminated within 1 day. This was accompanied by a deposition of over 30 per cent in the skeleton and over 20 per cent in the liver. Presumably citrate breaks up the insoluble colloid in which Pu exists in the lungs. Complexing with cupferron which, unlike citrate, produces a "fat soluble" compound, greatly diminished the extent of absorption from the lungs. Plutonium oxide smokes which were produced at high temperatures were eliminated more slowly from the lungs (average half time of 30 days during the first month) and were deposited in the skeleton to a much lesser extent (6.2 per cent) than was the case with the nitrates.

MDDC - 678 Variation in Yield Among Members of Fission Chains, by R. M. Adams, et al 1 p.

This paper is an abstract and the whole text is reproduced here.
A detailed study of the distribution of nuclear charge among the primary fission products has not yet been made. Scattered data have been obtained, however, which shed some light on this interesting problem.

The independent fission yields of four isotopes close to stability, namely, 34h. Br^{82}, 19.5d. Rb^{86}, 9.2h. Xe^{135}, and 13d. $Cs^{(136)}$, have been measured and found to be a small fraction of the total chain yields. Three of these isotopes, Br^{82}, Rb^{86}, and $Cs^{(136)}$, are "shielded" isotopes and cannot be formed by normal β-decay processes. Apparent increases in the total fission yields of succeeding members of fission chains have been observed in chains of mass 91, 141, and 143.

More data have been supplied by investigations on active krypton and xenon isotopes. The identification of both these elements in chains of complementary mass numbers is not consistent with a unique charge splitting on fission, since the sum of the nuclear charges of Xe and Kr (90) is less than that of uranium. The fractions of chains swept out of uranium solutions while being irradiated bears out this idea.

The independent yield data indicate that the most probable charge lies about 3.5 units from stability, with a sharp decrease in yield occurring away from the most probable charge. A good correlation of this data has been made on the assumptions of equal charge displacement from stability of complementary chains and a universal yield vs. charge increment relationship over the whole mass spectrum.

MDDC - 679 The Use of the Szilard-Chalmers Reaction to Prepare Radio-isotopes in High Specific Activity, by A. W. Adamson, et al 1 p.

This paper is an abstract and the whole text is reproduced here

Radio-isotopes produced by the n, γ reaction are often found in chemical states different from the target substance, permitting separation of the fractions by chemical methods. The recoil impulse given the capturing atoms by the gamma ray emitted will usually disrupt molecular species containing the activated atoms.

Decomposition of the material bombarded by the pile radiations without nuclear activation often hinders the separation of radio-isotopes in high specific activity through the production of stable isotopes in the same chemical state as the radio-isotopes, Assuming a first order rate law, an equation can be derived which includes this effect and relates enrichment to duration and intensity of bombardment.

A second disadvantageous effect observed is the loss of chemically separable activity because of a radiation-induced reaction which returns the activated atoms to the same chemical states as the target substance. This factor can be discussed quantitatively.

The proportion of Sb^{122} and Sb^{124} separable from several compounds of Sb after neutron bombardment and the specific activity of the separated fraction have been studied. Similar observations have been made on Fe^{59} from $K_4Fe(CN)_6\ 3H_2O$. The results have been compared with the theoretical expressions.

MDDC - 680 The Chemical and Radiochemical Identification of Isotopes of Nd and Element 61 Formed in Fission by N. E. Ballou, L. E. Glendenin, J. A. Marinsky, J. Sellar and L. Einsberg, 1 p.

This paper is an abstract.

Advances have been made in the fractionation of rare earth elements which lead to the positive chemical identification of two isotopes of element 61 formed in fission and formed from neutron activation of Nd. Fractionations of rare earth elements are carried out by adsorption from dilute solution on a column of organic ion exchange resin, followed by elution with citrate buffers (~5% at pH~3). Tests show that the order of elution is the reverse of that of atomic number.

Application of this technique to a mixture of rare earth fission activities freed chemically of members other than La, Pr, Nd, and element 61 identifies an 11 day β and γ emitter first detected by T. H. Davies, as a Nd isotope, and a 3.7 year soft β emitter and a 47 hour β and γ emitter as isotopes of element 61. Fission yield studies and growth curves indicate that the mass assignments are 147, 147, and 149, respectively.

This first positive identification of element 61, whose existence has not been established in nature, has been made by two of the authors, Marinsky and Glendenin. They propose the name Promethium, symbol Pm, for the element.

MDDC - 681 Theoretical Considerations Regarding Minimum Pressure for Stable Arc Operation by D. Bohm. 28 p.

Surrounding the filament is a double sheath containing ions drifting in from the plasma and electrons emitted thermally by the filament. The maximum electron current that can be drawn from this sheath is

$$J_e = \gamma \sqrt{\frac{m_+}{m_e}}\, J_+ \qquad (1)$$

where $\left(\frac{m_+}{m_e}\right)$ is the ratio of ionic to electronic mass, J_+ is the positive ion current reaching the sheath from the plasma, and γ is a correction factor depending on the age of the filament varying from 2/3 to 1/3.

Equation (1) provides an upper limit to electron emission from the filament. When the number of ions returning to the filament per electron emitted falls below this limit, the arc will become hashy or go out. Since the rate of generation of ions is proportional to pressure, there will be a minimum pressure below which the arc does not function properly because too few ions reach the filament sheath to satisfy the requirements given in equation (1)

There are two factors determining the value of this minimum pressure: first, the number of ions generated per electron, and second, the fraction of these ions reaching the filament sheath. Any process increasing either of these

(Cont'd on next page)

MDDC - 681 **Theoretical Considerations Regarding Minimum Pressure for Stable Arc Operation by D. Bohm. 28 p.** **(Cont'd from page 437)**

quantities will decrease the pressure required for stable operation. A great deal of work, both theoretical and experimental, has been done on both factors mentioned above. In Sections II, III, and IV of this paper enough of the results of the detailed work are quoted to discuss the minimum operating pressure for the argon arc.

If the arc meniscus is brought closer than a certain critical distance, "d," which is specified in Section V, it begins to rob the arc column of ions so rapidly that the fraction reaching the filament sheath is reduced, and the minimum operating pressure is raised.

Theoretical and experimental investigation thus far has been confined mainly to argon.

The magnetic field may have a number of interesting effects on the withdrawal of electrons through the filament sheath. However, they are complex, and not yet very clear.

MDDC - 682 **Laboratory Techniques in High-Level Radiochemistry, by E. L. Brady et al 1 p.**

This is an abstract only and the whole text is reproduced here.

The use of piles for production of large quantities of highly radioactive materials introduces new and difficult problems of laboratory technique. A two-fold hazard is faced: Contamination of laboratory and equipment by radioactive materials, with consequent invalidation of radiochemical results; and health damage to personnel because of radiation and toxicity. Satisfactory techniques demand extreme cleanliness in operation and, depending upon the magnitude of the radiation source, a greater or lesser degree of remote control.

MDDC - 683 Long-Lived Zirconium and Columbium Isotopes in Fission, by E. L. Brady, et al 1 p.

This paper is an abstract only and the whole text is reproduced here.

A brief description of the pre-Project status of long-lived Zr and Cb isotopes is given. The discovery of and establishment of the genetic relationships in the prominent chain

$$\rightarrow 65\text{ d. } Zr^{95} \rightarrow \begin{matrix} 90\text{ h. } Cb^{95} \\ 35\text{ d. } Cb^{95} \rightarrow \end{matrix}$$

in uranium fission is discussed. No other major isotopes with half-lives between 17 h. and 65 d. in the case of Zr, or between 90 h. and 35 d. in the case of Cb have been detected in fission.

The isolation of these isotopes from neutron irradiated uranium involved standard radiochemical techniques.

Studies of the radiation characteristics of these isotopes by absorption in Al and Pb, by coincidence counting, and by analysis of the beta spectra with a spectrometer indicate that the decay of the 65d. Zr and 35d. Cb involve the emission of beta and important gamma radiation, whereas that of the 90h. Cb is accompanied by X-rays and conversion electrons associated with the isomeric transition to the 35 d. Cb.

The mass assignment of this chain is also discussed.

MDDC - 684 Quarterly Report, August to October, 1946 Biology Division by A. M. Brues 65 p. January 14, 1947.

This is the first quarterly report of the Biology Division of the Argonne National Laboratory. Groups reporting are listed as follows: Administration, Editorial Group, Animal Maintenance. Radiochemistry, Radiation Physics, Radioautography, Hematology, National Cancer Institute Group, Statistics, Histology, Physiology, Experimental Surgery, Experimental Pathology, Biochemistry, Physical chemistry, Biophysics, and Microbiology.

MDDC - 685 Colorimetric Measurements of Gross Fission Product Decay Energy by C. V. Cannon, R. A. Day 1 p.

This is an abstract only and the whole text is reproduced here.

Direct measurements of the rate of energy liberation of fission products were made using an adiabatic calorimeter. The technique used measured directly all of the energy from β decay and most of the energy from γ decay of the fission products. Estimates have been made of the γ energy not detected by the calorimeter.

Uranium metal samples were irradiated in the Clinton Laboratories pile for time intervals varying from 1 day to 122 days. The measurements were made at times varying from 30 minutes to 60 days after withdrawal from the pile.

A family of curves giving wattages for various times of irradiation and cooling has been constructed from the experimental data. (These are not included in this report).

MDDC - 686 The Requirements of an Adequate Health Service in Relation to Atomic Research and Industrial Development, by S. T. Cantril, J. J. Nickson, J. E. Wirth, R. S. Stone 16 p.

One purpose of the Health Service in association with a research laboratory or industry is to promote an environment for work free from those deterrents to health which arise because of the occupation. A second purpose is to see that the public is not endangered by the operations.

A well rounded Health Service in the field of atomic research, development and production should include both (1) Medical Service and (2) Hazard Control in its program.

The distinctly medical services such as preemployment examinations, periodic physical and laboratory examinations, terminal examinations, first aid and dispensary care, general health advice and education, development of tests of biological damage, and the keeping of adequate records are discussed.

Control of hazards must be exercised in several ways, the main ones being -

(a) Consultation on plans and specifications before construction.
(b) Continuous monitoring of working conditions.
(c) Continuous monitoring of individual exposure.
(d) Education of personnel regarding hazards.
(e) Education of personnel regarding safe techniques.
(f) Adequate clear records.
(g) Research facilities to check calculations and detect unknowns.

MDDC - 687 Chemical Effects Following Nuclear Transformations, by T. H. Davies 1 p.

This paper is an abstract only and the complete text is reproduced here.

After thermal neutron capture, the recoil impulse given the capturing atom by the very energetic gamma ray immediately emitted, will usually disrupt molecules of which the capturing atoms are a part. Thus, under favorable solution conditions, all Mn^{56} from bombarded $KMnO_4$ is found in a state separable with carrier MnO_2. In many cases, not all of the activated species is found in a new chemical state. Resynthesis of the target substance is indicated here.

The chemical changes observed in atoms emitting soft, "delayed" gamma rays can usually be ascribed to the internal conversion of this radiation and the loss of many peripheral electrons through the Auger process. Thus in the decay of the excited state of Te^{132} present in aqueous solution as $TeO_4^=$ ion, the loss of several orbital electrons through conversion of the gamma ray produces an unstable molecular species which dissociates and is finally stabilized as $TeO_3^=$.

The emission of nuclear electrons generally means a new chemistry for the product atoms by virtue of the change in atomic number. In selected cases, however, the chemical state of the daughter atom should be predictable from that of the parent. For example, the β^- decay of $Se^{83}O_3^=$ should yield $Br^{83}O_3^=$. The observation that the major part of the product bromine is present in more reduced forms suggests the coupling of nuclear and chemical processes of an as yet unidentified character.

MDDC - 688 Spectroscopic and Photochemical Properties of Uranium Compounds With Particular Reference to Isotopic Separation by G. H. Dieke and A. B. F. Duncan. 437 p.

A separation of an isotopic mixture can be effected if the two isotopes have differences in their absorption spectra.

For the success of a photochemical separation of uranium isotopes, the following three conditions have to be satisfied simultaneously:
1. There must be a difference in the absorption spectrum of a compound with U^{235} compared to the spectrum of the same compound made with U^{238}. This difference may be either in the position or the intensity of an absorption line.
2. It must be possible to illuminate the compound with light containing the absorption frequency for U^{235} but not for U^{238} or at least a preponderance of the former. In this way the molecules containing U^{235} are more readily excited than those containing U^{238}.
3. There must be chemical reaction which affects the excited molecules and removes them. For this it is important that the excitation energy cannot be exchanged from a 235 to a 238 molecule before the reaction can occur.

A great deal of progress has been made in understanding the structure of the uranyl compounds and their spectra, and the foundations laid for further work in this field.

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MDDC - 688

Spectroscopic and Photochemical Properties of Uranium Compounds with Particular Reference to Isotopic Separation by G. H. Dieke and A. B. F. Duncan. 437 p. (Cont'd from page 441)

1. The absorption and fluorescence spectra of a great variety of uranyl compounds have been photographed at the temperature of liquid hydrogen at a dispersion and resolving power sufficient to resolve the full structure of the spectra.
2. A few of the compounds giving very sharp lines have been studied in detail. The structure of the spectra is richer than hitherto recorded. For example, 237 lines were measured in the fluorescence spectrum of $CsUO_2(NO_3)_3$, and 616 in the absorption spectrum.
3. The principal lines were classified and assigned to the proper UO_2 frequencies. A number of other vibrations were identified definitely, for instance frequencies of the NO_3 and acetate ions.
4. Many lines show hitherto unsuspected fine structure.
5. The absorption spectra consist of a number of distinct electronic transitions on which are superimposed molecular vibrations. Beyond 3360 A there is continuous absorption. This limit is slightly different in different compounds.
6. In uniaxial crystals the lines belonging to one electronic transition are split in a magnetic field and have the normal Zeeman separation. These lines are split in biaxial crystals without an external field.
7. Quantitative intensity measurements were obtained for fluorescence and absorption. The latter show that the f number of an individual line is of the order of magnitude 10^{-7} to 10^{-8} at 77°K. There is evidence that intensity ratios depend on the temperature.
8. There is inconclusive evidence that intensity ratios are affected by a magnetic field.
9. The effect of temperature on the spectra of these two compounds was studied. The lines are broadened and shifted, but this effect is considerably smaller in the chloride than in the nitrate.
10. Other uranium compounds including UF_6 were studied with less detail.
11. A number of impurities probably due to hitherto unobserved uranyl compounds were observed, and a very efficient analytical method developed for the detection of uranium and other compounds, including the isotopes of most elements that can be incorporated into a uranyl salt.
12. It was found that there is no exchange of oxygen between the UO_2 and the NO_3 ions in the double uranyl nitrates.
13. Partial substitution of another alkali into the lattice of an alkali double nitrate broadens and displaces the fluorescence lines.
14. A preliminary study of photochemical reactions with uranium compounds was made.
15. A number of observations are reported on the preparation of uranium compounds. This includes the preparation of crystals from very small amounts of materials and from unusual starting materials which were necessitated by the isotopic substitutions.

The results achieved in this work regarding the U-isotope effect of $CsUO_2(NO_3)_3$ and $Cs_2UO_2Cl_4$ can be summarized as follows:

16. There are changes in the absorption spectra of uranyl compounds with U^{235} as compared to the same compounds with U^{238} which in principle may be used for a photochemical separation of the two isotopes.

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MDDC - 688 Spectroscopic and Photochemical Properties of Uranium Compounds With Particular Reference to Isotopic Separation by G. H. Dieke and A. B. F. Duncan. 437 p. (Cont'd from page 442)

17. The maximum shift observed is 1.8 cm^{-1}.
18. The two compounds studied, $CsUO_2(NO_3)_3$ and $Cs_2UO_2Cl_4$, behave very differently, and there is the possibility, although remote, that other compounds may have more favorable isotope effects.
19. There is no definite experimental proof for or against the possibility that under certain conditions there are considerably intensity differences.
20. Isotopic substitutions of N^{15} and O^{18} in addition to U^{235} have contributed substantially to an understanding of the structure of these spectra.
This understanding is very essential for planning any further work.
Suggestions for future work tables of wave lengths and frequencies, and an extensive bibliography are also included.

MDDC - 689 Chemical Effects Accompanying the Decay of Radioactive Selenium to Bromine, by T. H. Davies, R. R. Edwards, and H. Gest 1 p.

This article is an abstract, the complete text of which is reproduced here. See MDDC-692 below.

Carrier-free Se^{83} and Se^{84} were isolated from fission product mixtures and Se^{83} was also obtained without carrier by a Szilard-Chalmers reaction with ammonium selenite. The radio-selenium was converted to aqueous $SeO_3^=$ or $SeO_4^=$ or to metallic Se in CS_2 solution. After an appreciable fraction had decayed to radioactive bromine, the chemical state of the latter was investigated. Silver bromide used as an adsorbent or exchange solid served to distinguish the more reduced forms from BrO_3^-. Ethylidine bromide, CH_3CHBr_2 was used as a test reagent to detect especially reactive forms of bromine.

Approximately 30% of the total Br activity was found as bromate in the experiments with aqueous solutions. The distribution was insensitive to variation in the initial oxidation state of the parent selenium, to substitution of Se^{84} for Se^{83}, and to change in the acidity of the decay solution. The decay of metallic Se in CS_2 yielded reduced Br. About 20% of the Br^{83} from aqueous $SeO_3^=$ decay combined with CH_3CHBr_2 suggesting the transitory presence of species more reactive than Br_2.

The decay of aqueous $SeO_3^=$ by β^--emission should yield BrO_3^-:

$$SeO_3^= \rightarrow BrO_3^- + \beta^-$$

The results, however, indicate extensive disruption of the production by the radioactive process. The recoil from the emitted β^- particle appears inadequate to give the results observed.

MDDC - 690 **Certain Chemical and Physical Properties of the Uranium Chlorides by C. E. Evans, 28 p. February 3, 1947.**

The properties and methods of preparing the various uranium chlorides and oxychlorides are described.

Uranium forms a series of polychlorides of definite composition, namely UCl_6, UCl_5, UCl_4, and UCl_3. On heating at atmospheric pressure, both UCl_6 and UCl_5 may be decomposed to UCl_4, which is very stable thermally. The anhydrous trichloride may be prepared by heating UCl_4 with a reducing agent, hydrogen being well suited for this purpose.

Results of investigations relating to the mechanism of the liquid phase chlorination of UO_3 and of phase studies of the system UO_3, H_2O and HCl are given. Results with HNO_3 and $HClO_4$ are also included for purposes of comparison.

MDDC - 691 **A Method for the Determination of Certain Metals Present in Minor Concentration in Various Substances by N. Howell Furman and C. E. Bricker 18 p.**

This paper presents a brief form an account of a systematic scheme for the determination of certain metals in a variety of substances.

The possibility of using a small mercury cathode as a collector for minor amounts of electrolyzable metals was explored and the procedure tested for a variety of applications.

A novel combination of techniques based on the distillation of the mercury from the cathode and the polarographic and colorimetric examination of the residue was devised and studied extensively in a rather limited range of applications. The procedure appears to be capable of many further applications to a great variety of organic or inorganic substances.

MDDC - 692 The Chemical Effects of Nuclear Transformations. I. β-Decay of Lanthanum to Cerium. II. β-Decay of Selenium to Bromine by H. Gest, et al. 30 p.

The formation of ceric ion from the decay of trivalent La^{143} has been demonstrated by the use of zirconium iodate as a specific carrier for Ce^{IV} in the presence of Ce^{III}. Of the Ce^{143} formed in the presence of the carrier-precipitate, ~57% was captured presumably as ceric ion. Since poor reproducibility was encountered in the test experiments, the failure of the remaining ~43% to carry cannot be definitely explained. Failure of oxidation in the decay process seems highly unlikely, so that instability of tracer Ce^{IV}, or failure to separate with the Zr iodate precipitate are postulated.

The results serve as an experimental demonstration of the oxidation expected as a result of electron (β^-particle) emission from an unstable nucleus.

The chemical states of the β^-decay products of radioactive Se and $SeO_3^=$, $SeO_4^=$ and Se metal have been investigated. Selenite and selenate ions lead to the formation of about 38% BrO_3^- and 62% reduced forms. In a single experiment 23% was found as atomic bromine. No BrO_3^- was detected among the decay products of Se as the metal under the experimental conditions employed. Little effect of pH on the nature of the products was observed, and no appreciable difference was observed between the products of Se^{83} and Se^{84} decaying as selenite ion.

MDDC - 693 The Evaporation of Gallium, by S. K. Haynes 1 p. (See also Physical Review Vol. 71 p. 832 June 1, 1947)

This article is an abstract, the complete text of which is reproduced here.

A thin β-ray source was made by evaporating gallium onto a thin sheet of polystyrene. Since gallium was not among the metals for which evaporation procedures were given by Olsen, Smith and Crittenden an investigation was made to find the best procedure. A modification of the procedure for aluminum was finally used. The gallium was warmed just above its melting point and "buttered" onto a cooler clean open helix of 30 mil tungsten wire, drop by drop, until the tungesten was almost covered. When the tungsten was flashed to a dull red in vacuum, a fraction of the gallium reacted with it, while the remainder dropped off. The tungsten retained all the gallium ready for the final evaporation after a second "buttering" and flashing. Several other methods were tried with less success, including a close wound conical helix of tungsten and a tantalum crucible heated by a filament.

MDDC - 694 Quantitative Chemical Isolation of Fission Product Radioactivities, by D. N. Hume
1 p.

This paper is an abstract the complete text of which is reproduced here.

The quantitative isolation of pure fission product radioactivities may be undertaken with any of three major objectives in mind. These are (1) preparation of "tracers", (2) preparation of sample for characterization of decay energies, genetic relationships and other fundamental properties, and (3) analysis of mixtures to determine the contribution of the various elements to the total radioactivity. The purpose of this paper is to outline the general methods used with the latter objectives in mind, and to provide by way of illustration one typical procedure in some detail.

In general, a known weight of inactive isotopes of the element desired is added to act as a carrier. Appropriate chemical operations are performed to ensure that complete interchange takes place between active and carrier atoms, and the element is separated and purified by ordinary chemical means until all radioactive contamination by other elements is removed.

The isolated pure radioactivity is determined. By weighing the purified sample the chemical yield of the isolation process is calculated and used to correct the observed radioactivity to one hundred percent recovery. Tested methods for all the fission elements from Zn through Eu (excepting only Kr and 61) have been developed and many are now on a rapid, routine basis. As an example, the isolation of pure fission zirconium activity from uranyl nitrate solution by a procedure involving the precipitation of barium fluozirconate, a new separation method for zirconium, is described in detail together with tests to show the validity and accuracy of the method.

MDDC - 695 Control Chart Method Applied to Errors in Radioactive Counting, by W. G. Schlecht. 29 p.

The study of weakly radioactive rocks and minerals by the Section of Chemisty and Physics of the Geological Survey has included determinations of radioactivity by Geiger-Muller counters. Many of the samples examined are so weakly radioactive that their effect on a counting instrument is of about the same size as that of the surroundings. The radioactivity to be determined thus may be near the natural limit of precision of the instrument, which is imposed by the local background effect. There is also another serious source of error in the determinations: the counting apparatus itself is delicate and is subject to many disturbances, some of them so subtle as to easily escape notice unless constantly watched for. It is therefore important that no precaution be overlooked that will help to avoid mistakes.

A series of experiments shows that the modern statistical methods developed by Dr. Walter A. Shewhart at the Bell Telephone Laboratories are very useful for handling problems arising from both of the sources of error mentioned, background fluctuations and instrumental defects. The Control Chart method is a practical approach both for indicating defective behavior of the counting instrument and for determining very weak radioactivities.

MDDC - 696 The Effects of Fast Neutrons on the Ability of Mice to take Forced Exercise, by G. E. Stapleton, H. J. Curtis. 17 p.

In an attempt to gain some insight into the physiological condition of mice surviving massive doses of radiation, a study of their vitality was undertaken. It was assumed that the ability of these animals to do forced work would be a measure of their vitality. Stimulating exposed animals to run in exercise wheels to their fullest capacity, has resulted in a demonstration of a striking vitality loss during a post-irradiative period, when no other effects are demonstrable by gross examination.

Mice subjected to a median-lethal dose of fast neutrons show a continuous vitality loss over a 300 day period following exposure.

Control animals show no appreciable loss of vitality up to about 8 months of age, after which a gradual loss can be noted, probably due to a normal gereologic process.

MDDC - 697 **Failure to Affect Toxicity of Ingested Uranium Chloride by Dietary Acid (HCl) or Base ($NaHCO_3$) by A. Tannenbaum, H. Silverstone. 11 p.**

The present study was designed to investigate the toxicity of the HCl released by hydrolysis of UCl_4, and at the same time acquire information on the modifying effects of moderate amounts of acid (HCl) or base ($NaHCO_3$) on the toxicity of ingested UCl_4.

Six groups of mice were fed a basic laboratory ration with the following addition:

M40: nothing added.
M43: 0.6% to 1.2% HCl.
M41: 0.8% UCl_4.
M44: 0.8% UCl_4 plus 0.46% HCl.
M42: 3.2 UCl_4.
M45: 3.2% UCl_4 plus 1.06% $NaHCO_3$.

With due consideration to the amounts of HCl liberated from UCl_4, and the amounts of added HCl or $NaHCO_3$, the data on growth of the mice, morphologic changes in the kidneys, and amounts of uranium found in the kidneys and bone indicate that: 1) HCl in itself did not account for any considerable part of the toxicity of UCl_4, 2) the addition of 0.46% HCl to the diet containing 0.8% UCl_4 did not augment the relatively slight toxicity of this dosage, and 3) $NaHCO_3$, which would presumably neutralize some of the acid, did not decrease the significant toxic action of the 3.2% dosage. In this experiment the most important factor in toxicity was the dosage of UCl_4 fed.

MDDC - 698 **Relationship of Uranium Excretion to the Total Amount of Uranium in the Mouse, by A. Tannenbaum and H. Silverstone 8 p.**

The rate of excretion of uranium accumulated in the tissues of mice was determined in two ways:

1) The amounts of uranium in the kidneys and bones of mice were determined at various times between 45 and 287 days following subcutaneous injection of uranyl nitrate. The total uranium in kidneys plus bone was found to decrease at the rate of 0.57% daily.

2) In another experiment the uranium excreted daily in urine plus feces was determined just preceding the sacrifice of the animals for analysis of tissues. The ratio of the uranium excreted daily to the uranium present in the body averaged 0.9%.

These excretory rates refer to the uranium that has been absorbed and fixed in the tissues; specifically excluded is the uranium excreted from sites of entry such as lungs, gastro-intestinal tract, or an injection site. The results indicate that the total uranium in the body may be estimated from the daily excretion of uranium (the former is approximately 100 to 200 times the latter), and that, of the uranium which has accumulated in the tissues, one-half is eliminated in about 70 to 140 days.

MDDC - 699

Methods for the Quantification of Radium, by P. C. Tompkins, W. P. Norris, L. Wish, R. D. Finkle. 50 p.

Two methods have been developed for the estimation of radium in preparations containing insignificant amounts of Ra D, Ra E and Po. One method depends on the counting of alpha particles from radium after sufficient aeration of a radium solution to remove radon and permit the decay of the short-lived disintegration products. This method is applicable to pure solutions of radium and its decay products. A second method, which may be applied to biological materials, requires the coprecipitation of radium with barium sulfate after radon has been removed by heating the radium in solution. The radon and short-lived daughters reach equilibrium within the barium sulfate crystals.

After a sufficient period of growth, beta rays from RaB and RaC are counted and compared with standard samples.

Large errors may be encountered in the latter method, due to self-absorption, unless one measures and corrects for the solid content of the capsules. Such errors, may be minimized or eliminated by increasing the distance between the capsule and the tube and/or interposing aluminum absorbers. A modification of the coprecipitation procedure with barium sulfate permits the analysis of biological or other materials containing excessive amounts of inert ash. The beta method has been successfully applied in the analyses of urine, feces and whole carcasses of rabbits, rats and mice.

MDDC - 700 Radiation-Induced Changes in Ultraviolet Absorption on Spectra of Urine; I General Effects, by L. Wattenberg and S. Schwartz, 31 p.,July 25, 1946. (CH-3541).

Several hundred ultraviolet absorption spectra (Beckman spectrophotometer) have been prepared from urine of control and irradiated dogs receiving either external or internal irradiation. Unless death occurs too soon (i.e., within less than two weeks) there is a consistent increase in absorption in the regions of 245, 310 and/or 270 mμ in acid solution.

The 235 and 310 mμ increases are shown to be due to kynurenic acid, a metabolic derivative of tryptophane. The 270 mμ increase is shown to be due to uric acid.

The effect on the spectra of variations in pH are described.

MDDC - 701 Radiations-Induced Changes in Ultraviolet Absorption Spectra of Urine: II, Quantitative Spectrophotometric Studies, by L. Wattenberg, 34 p.,January 14, 1947. (CH-3661).

Methods are described for the quantitative estimation of kynurenic acid in dog urine. These are based on analysis of the ultraviolet absorption spectrum either of unpurified diluted urine or of purified urine extracts.

Urine kynurenic acid excretion has been studied in 13 mongrel dogs administered lethal amounts of X ray in either single or multiple doses. Twelve of the animals showed an increase in urine kynurenic acid concentration at some time shortly before death. This increase is best seen in the urine ultraviolet absorption spectrum as a plateau or actual maximum at about 245 mμ. Because of diminished terminal per diem urine volume in several dogs, the per diem excretion of kynurenic acid rose significantly in only ten animals, with questionable increases in two of the others.

Two dogs injected with plutonium were also studied. One, which died after 90 days, showed a terminal increase in urine kynurenic acid excretion. The other, which died 234 days after receiving the plutonium excreted very little kynurenic acid throughout its course. This dog showed the most evidence of liver damage of any of the dogs studied.

Data are insufficient to interpret the findings adequately. Some of the factors that may be involved in kynurenic acid excretion are discussed.

MDDC - 702 Boundary Conditions at Interface between Medium and Vacuum; The extrapolation Distance, by A. M. Weinberg, 14 p., n.d., decl. 2/26/47.

Elementary diffusion theory is used to evaluate the boundary conditions at the interface between medium and a vacuum in general mathematical terms. A formula is derived for use in pile neutron physics, using the albedo, for calculating the fraction of the net neutrons current absorbed in a sheet, where the net current of neutrons in a weakly absorbing medium is known and a thin, weak absorbing sheet is placed normal to the neutron flux gradient.

It is stated that the net diffusfon current through a channel depends upon (1) the dimensions of the channel; (2) the orientation of the channel with respect to the neutron flux gradient; (3) the scattering properties of the medium in which the channel is placed; (4) the flux distribution. Because the flow per unit gradient depends on the orientation of the channel, if a medium is traversed by a large number of parallel channels the net diffusion current will be anisotropic, i.e., the diffusion coefficient is a tensor.

This current is computed, using essentially the method of Nordheim and Soodak.

MDDC - 703 Decomposition of Solid Barium Nitrate by Fast Electrons, by A. O. Allen and J. A. Ghormley, 4 p., December 30, 1946. (See also Journal of Chemical Physics, Vol 15, p. 208-209, April 1947).

The behavior of irradiated salts on solution is an almost unexplored subject, which has become of interest recently in connection with production of radioisotopes.

Ordinary C. P. grade barium nitrate crystals were irradiated with a beam of 1.2 Mv electrons from a Van de Graaff generator. On dissolving the irradiated salt in water, copious effervescence occurred, and nitrate was found in the solution.

Formation of gas and nitrite on solution of barium nitrate irradiated with 1.2 Mv electrons at a rate of approximately 1.5 watt/g.

Irradn. time, hr	% NO_3^- converted to NO_2^-	Gas formed, cc/g. (22°C., Approx. 73 cm.)	Calcd, O_2 equiv. to NO_2^- found, cc/g. (22°C., 73 cm.)
2.8	5.5	5.9	4.9
6.0	10.5	10.1	9.0
9.6	13.0	12.8	11.5
13.0	18.0	16.4	16.0
17.3	21.1	19.0	18.9

MDDC - 704 The Preparation of Pressed Ra + Be Neutron Sources, by H. L. Anderson and B. T. Feld, 1 p.,n.d., decl. 12/19/46. (See also Review of Scientific Instruments, Vol. 18, p. 186,March 1947.)

This paper is an abstract and the whole text is reproduced here.

Techniques have been developed for the production of compact, stable mixtures of radium bromide and beryllium for use as sources of fast neutrons. A density of 1.75 gms/cm^3 has been achieved, allowing sources as strong as 5 gms of radium in 25 gms of Be to be fabricated in such a manner that they are effectively point sources.

The essential steps involve purification of the materials, careful preparation of the powder mixture, and subsequent pressing in a hydraulic press employing pressures as high as ten tons per square inch.

Stability of sources made in this way results from the fact that there is no shift of crystals as is ordinarily encountered in powder mixtures. It has been found that $RaBr_2$ sources may be prepared in the same way, resulting in densities of approximately 4 gm/cm^3.

MDDC - 705 Alpha Hand Counter Mark 10 Model 10A, Argonne National Laboratory, 2 p.,n.d., decl. 1/9/47.

This instrument is used to determine the presence of alpha emitting materials on the hands.

The meter range is 20 to 10,000 counts per minute. The yield of the detector unit, an air proportional counter, is about 20%. Thus the meter reads alpha contaminations of approximately 100 to 50,000 disintegrations per minute.

The air proportional counter, Mark 17, Model 10B, is operated from a regulated high voltage supply which is variable from 1500 to 2500 volts positive. The pulse from the detector is fed into a resistance-capacitance coupled negative-feedback wide band amplifier with a gain of about 300 and a frequency response down 3 decibels at about 20,000 and 1,000,000 cycles. A trigger-pair serves as a pulse-height selector and also furnishes pulses of a standard size and shape to the logarithmic counting rate meter. An alarm circuit flashes a red light when a predetermined counting rate has been passed. A neon light on the front panel controlled by a resistance-capacitance circuit goes on when the operator inserts his hands, and remains on until a time (10 to 20 seconds) has passed, allowing the meter to approach its final reading.

Because of the high voltage and high input sensitivity (2 millivolts), it is necessary to select the input filter and coupling condensers. For a filter condenser the Glassmike (Condenser Products Company) is chosen; for a coupling condenser the Centralab #850 is used. These are found to be the only condensers of many tested that can be used. Heaters are placed on the air proportional counter units to eliminate humidity problems which are present in the counter at very high humidity levels. Total weight, about 100 lbs. Circuit diagram included.

MDDC - 706 The Total Disintegration Energy of Na^{24} by E. C. Barker. 1 p.,n.d., decl. 2/17/47. (See also Physical Review Vol. 71,p. 453, April 1, 1947.)

The whole document is reproduced here.

Coincidence measurements have shown that the two γ rays of Na^{24} are probably emitted in cascade. They have energies of 2.76 and 1.38 Mev. Sachs has pointed out that if they are in cascade, the disintegration energy of Na^{24} may be higher than would be expected according to the considerations of Barkas. The following is the result of a different kind of experiment which bears directly on the same question. This was a measurement for Na^{24} analogous to that which was made for RaB and RaC by L. H. Gray. In this type of experiment, the source is placed in a large block of aluminum, and distribution measurements of the γ energy absorbed in the aluminum are made with small ionization chambers. Integration gives the total γ energy emitted per second from the source and a determination of the β strength gives the average γ energy emitted per β particle. In the case of Na^{24} the β decay is simple, and the result is interpretable as the γ energy accompanying each disintegration.

Measurements with two separate sources gave the γ energy per disintegration as 4.15 Mev and 4.19 Mev respectively, assuming 32.5 ev as the energy required to produce an ion pair. Adding the beta disintegration energy of 1.39 Mev, one obtains 5.56 Mev for the total disintegration energy of Na^{24}.

MDDC - 707 Calculation of Equilibrium Constants for Isotopic Exchange Reactions by J. Bigeleisen and M. G. Mayer, 22 p.,n.d., decl. 1/30/47. (See also Journal of Chemical Physics, Vol. 15, p. 261-267, May 1947).

It is pointed out that the possibility of chemical separation of isotopes is a quantum effect. This permits a direct calculation of the difference in the free energies of two isotopic molecules. Tables and approximation methods are given which permit a rapid calculation of equilibrium constants if the frequecny shifts on isotopic substitution are known. Several applications are discussed.

MDDC - 708 The Exchange Adsorption of Ions from Aqueous Solutions by Organic Zeolites I. Ion-Exchange Equilibria, by G. E. Boyd, J. Schubert, and A. W. Adamson, 31 p., n.d., decl. 2/7/47. (See also Journal of the American Chemical Society, Vol. 69, p. 2818-2829, November 1947.)

The problem of accurate formulation of the relations governing the equilibrium behavior of exchange adsorption systems; the experimental testing of these equations; and the generalizations concerning the adsorbab'lity of cations arrived at are treated.

1. The equations describing base-exchange reactions may be formulated either on the basis of an adsorption mechanism or according to the law of mass action. These relations can be shown to be entirely equivalent formally.

2. Results from experimental measurements of the standard free energy of formation, ΔF^{o}_{MR}, of the metallic zeolite salt gave the following order of adsorption affinity: $La^{+++} > Y^{+++} > Ba^{++} > Cs^{+} > Rb^{+} > K^{+} > Na^{+}$ $Li^{+} > H^{+}$.

3. Adsorption affinities were shown to be determined chiefly by the magnitude of the charge and the hydrated radius of the ions in solution.

MDDC - 709 Concentration of the Isotopes of Mercury by Free Evaporation in a 10-Cell Counter-Current Reflux Still, by A. Keith Brewer and S. L. Madorsky, 28 p., n.d. (See also Journal of Research of the National Bureau of Standards, Vol. 38, p. 129-135, January 1947.)

The results presented in this paper demonstrate that a series of individual molecular stills can be arranged in counter-current reflux in such a manner that the throughput between cells is entirely controlled by gravity feed. In the apparatus described, the separation coefficient, ϵ, for each of the , n, number of cells is comparable to that obtained in conventional single stage molecular stills for the same evaporation rate. The overall separation factor, S, has the same significance as in any counter-current reflux column, i.e.,

$$S = \epsilon^{n}$$

The advantages of the present reflux still over the single stage still are many: (1) The quantity of material required to give a desired separation is materially smaller. (2) The holdup is vastly lower. (3) The time required for a given separation is very much shorter. (4) The labor involved is less; this is illustrated by the fact that to realize the separation obtained in one operation in the present 10 compartment still, 55 individual recombinations and distillations would have to be made with single stage stills. (5) The operation can be made continuous; the material to be concentrated can be fed into the system at one end or at the midpoint, if both light and heavy fractions are of interest, and the concentrate can be withdrawn continuously at the ends. (6) The entire separation can be run without exposing the material to the atmosphere; this is particularly desirable in the case of liquids which are susceptible to decompositon upon exposure to air.

MDDC - 710 Initial Performance of the 184-Inch Cyclotron of the University of California, by W. M. Brobeck, et al.,5 p., December 27, 1946. (BP-52) (See also Physical Review, Vol. 71, p. 449-450, April 1, 1947).

The satisfactory results of the experiments performed on the 37-inch cyclotron (MDDC-41) led to the decision to complete the 184-inch cyclotron then under construction as a frequency modulated machine. This note describes briefly the equipment and experiments by which deuteron and alpha-particle beams of approximately 200 and 400 Mev respectively have been produced.

The angular velocity of such ions in a magnetic field decreases by 11 percent due to the relativistic increase in mass during acceleration. In addition a radial decrease of magnetic field, essentially linear from the center to a value of 95.4 percent of the central field at a radius of 80 inches, is provided to focus the ion beam properly.

MDDC - 711 Evidence for a γ -p Process in Be^9, by L. Brown, R. Conklin, and W. Ogle 8 p., October 23, 1946. (LADC-309). (See also Physical Review, Vol. 71, p. 378, March 15, 1947, for abridgement of this paper.)

An effort was made to find a substance in such a position on the isotope chart that activities attributed to γ-p process would not be confused with N-P reactions Be^9 seemed to be such a substance. The only confusing process is a n-α on Be^9 producing He^6.

A rough experiment indicated that when Be^9 is exposed to 23-Mev gammas from the betatron an activity is induced that has a half-life of the order of one second. A more careful measurement, made by swinging the beryllium on a pendulum arm from the gamma-ray beam to a position a few millimeters from a glass Geiger tube and photographing the interpolator lights on a scalar, gave a half-life of 0.9 ± 0.2 sec. As this was considered not to be sufficiently accurate, another measurement was made by placing the counter tube against the beryllium in the beam and irradiating both. Thus counting could begin a few tenths of a second after irradiation and a higher counting rate achieved.

He^6 is known to decay with the emission of beta particles with maximum energy of 3.7 Mev while Li^8 is known to decay with the emission of betas having a maximum energy of 12 Mev. Thus a simple absorption measurement should indicate the presence of either He^6 or Li^8. Such an experiment was performed by dropping the beryllium into position in front of a counter tube with Al absorber between the two, and counting the number of pulses in the interval between 0.3 and 1.3 seconds after irradiation. The absorption curve obtained indicates that there are beta particles of energy up to 13 Mev thus showing that Li^8 is formed. A lower energy component also appears and must be due to He^6.

MDDC - 711 Evidence for a γ-p Process in Be^9, by L. Brown, R. Conklin, and W. Ogle, 8 p., October 23, 1946. (LADC-309). (See also Physical Review, Vol. 71, p. 378, March 15, 1947, for abridgement of this paper). (Cont'd from page 455).

In order to separate the effects of the two products and to be sure that the half-life of the high-energy (Li^8) component is the correct order of magnitude, a rough measurement of the half-life was made with 9/32" of Al between the beryllium and the counter tube. The same dropping technique as above was used, and the number of pulses obtained in the first second of counting, the first two seconds, the first four seconds, etc., was observed. The growth curve obtained from these data gives a half-life of 1.0 ± 0.2 sec. This corresponds to the Li^8 period. Since 9/32" of Al absorbs all beta particles of energy less that 3.9 Mev, this should exclude the possibility of counting the betas from He^6 during this experiment.

Using the same dropping technique a curve of beta activity vs. maximum bremstrahlung energy from the betatron was run with 5/16" of Al between the beryllium and the Geiger tube. The two tests indicated that the γ – p process has an energy threshold of 18 ± 1 Mev which compares with the Segre figures of 16.8 Mev.

MDDC - 712 The Effect of Adrenal Cortical Injury on the Toxicity of X-rays by B. N. Carver. 6 p.,n.d. decl. 12/31/46.

Evidence is presented that rats whose adrenals are protected from X-ray irradiation are less susceptible to its lethal effects than rats receiving equivalent doses but not so protected. The possible relation of the adrenal-lymphoid system to irradiation sickness and the lethality of X-ray is discussed.

MDDC - 713 Interference Phenomena of Slow Neutrons, by E. Fermi and L. Marshall, 24 p.,n.d., decl. 1/27/47. (See also Physical Review,Vol. 71, p. 666-677, May 15, 1947).

Various experiments involving interference of slow neutrons have been performed in order to determine the phase of the scattered neutron wave with respect to the primary neutron wave. Theoretically this phase is change is very close to either 0° or 180°. The experiments show that with few exceptions the latter is the case. The evidence is based on the following types of measurements: (a) Measurement of the intensities of Bragg reflection of various orders of many crystals and comparison with the theoretical values of the form factor, (b) Total scattering cross section of gas molecules for wave lengths long compared with the molecular dimensions, and (c) Determination of the limiting angles for total reflection of neutrons on various mirrors. The elements Ba, Be, C, Ca, Cu, F, Fe, Mg, N, Ni, O, Pb, S, and Zn were found to scatter neutrons with 180° phase difference; Li and probably Mn scatter with zero phase difference. The five elements I, Br, Cl, K, and Na behave alike and the phase with which they scatter is tentatively identified as 180°. Coherent scattering cross sections have been determined for several elements.

MDDC - 714 Amplifier Response, by R. P. Feynman, 15 p.,August 2, 1946. (LADC-358)

The response of amplifiers to sharp pulses and step pulses is studied for amplifiers with various kinds of attenuation functions at high and at low frequencies. Graphs are included to illustrate the results.

MDDC - 715 Standardization of the pD Scale, by R. B. Fischer and R. A. Potter, 10 p., September 12, 1945. (CC-3271).

The purposes of this study are to standardize the pD scale for heavy water and to determine how the pD may be measured on the usual type pH meter.

The pD scale has been standardized by a method similar to that originated for pH standardization by Cohn. When the Beckman pH meter is used for measuring pD of heavy water, the correct pD, which this paper has defined as $pD = -\log C_D + {}^{o}\gamma_D + {}^{o}$, is obtained by added 0.25 units to the "apparent pH" reading.

MDDC - 716 (α,n) Cross Sections of Beryllium Magnesium, and Aluminum, by I. Halpern, 12 p. September 19, 1946. (LADC-301).

The (α,n) cross section for Be, Mg, and Al were measured as a function of α energy up to the full energy of polonium α's. The cross sections were determined by counting the neutrons released in the reactions in a graphite block with a slow neutron counter. The energy response of the counting apparatus was reasonably "flat" as it would have to be to give significant results.

MDDC - 717 Plutonium Hydride and Deuteride by I. B. Johns. 12 p., September 14, 1944. (LADC-277)

Data are presented showing the relationship between pressure, temperature, and composition of the hydride and of the deuteride of plutonium. The hydride is shown to have the composition represented by the formula PuH_3 at room temperature when the hydrogen pressure is approximately 350 mm Hg. At 200 mm the atomic ratio is 2.97, at 25 mm 2.925, and at 2.4 mm 2.892.

From the 400°C and 500°C isotherms it is evident that the reaction of the metal with hydrogen proceeds in the following steps:

$$(1)\ Pu + H_2 \rightarrow PuH_2,$$

The Pu and PuH_2 being separate phases;

$$(2)\ PuH_2 + \tfrac{1}{2}H_2 \rightarrow PuH_3,$$

The PuH_2 and PuH_3 being in solid solution in one another.

The heat of the first reaction is calculated to be -32,500 cal/mole. The heat of the second reaction varies with the composition. When H/Pu=2.6 the differential heat of reaction is -9,550 cal/mole while at the ratio H/Pu=2.87 it is -6,180 cal/mole.

The pressure-composition curves for the deuteride are parallel to those for the hydride at the same temperatures. At corresponding compositions the pressures from the deuteride are about 1.45 to 1.50 times greater than those from the hydride.

MDDC - 718 A General Purpose Linear Amplifier, by W. H. Jordan and P. R. Bell, 8 p., December 18, 1946. (See also Review of Scientific Instruments, Vol.18, p. 703-705, October 1947).

An attempt has been made to design a reliable general purpose amplifier that can be built in some quantity and will yet perform uniformly. It is sufficiently flexible that it can be used for most experiments involving proportional counters, electron collection in ionization chambers, and particle counting with secondary electron multipliers. Nothing basically new or original is claimed for this amplifier, but is is believed that the general design and layout is a step forward and will be of general interest. A great deal of the electrical design on the video amplifier section was taken from the Model 500 amplifier developed by Sands and Elmore at Los Alamos.

The main amplifier is divided into three parts, the video amplifier, the pulse height selector, and the power supply.

The video amplifier consists of two cascaded sections and a cathode follower output tube. Each section has two gain stages and a cathode follower. Degenerative feedback is used from cathode to cathode to stabilize gain, the feedback ratio being about 30. The high frequency cutoff of the first section can be varied by means of the selector switch which is ganged to the differentiation switch. As the bandwidth is decreased the gain is increased by changing the feedback resistor so the noise at the output terminal of the amplifier remains approximately constant. In the wide band position the gain of each section is 100.

The amplifier must be used with a preamplifier. For proportional counters and fission chambers, this need be nothing more than a single cathode follower. Other applications require more gain, so a four stage preamplifier with a gain of 30 has been built. The circuit used is similar to the Los Alamos Model 500 preamplifier.

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MDDC - 718 A General Purpose Linear Amplifier, by W. H. Jordon and P. R. Bell, 8 p., December 18, 1946. (See also Review of Scientific Instruments, Vol.18, p. 703-705, October 1947). (Cont'd from page 459).

The layout and wiring is such as to keep stray capacities and inductance to a minimum and yet keep all components where they are readily accessible for servicing. Ratings and quality of components were chosen with a view to reliable operation under constant duty. Complete construction details may be obtained from the authors by anyone desiring to duplicate this unit.

Circuit diagrams and photographs are included.

MDDC - 719 Metabolism of Plutonium, by W. Langham, et al., n.d., decl. 2/18/47 (LADC-222) 22 p. (See also The Journal of Biological Chemistry, Vol. 171, p. 273-283, November 1947).

The purpose of the experiments conducted at this laboratory was to study the effect of citrate ion concentration, valence state, and various other factors on the body distribution and excretion of plutonium following its intravenous administration to the rat.

The first day following intravenous injection of $PuO_2(NO_3)_2$ the urinary excretion of plutonium was 7.5 per cent of the dose as compared to 0.33, 0.57, and 0.71 per cent when administered as $PuCl_3$, $Pu(NO_3)_4$, and Pu^{+4} citrate complex respectively. Fecal excretion during the first day was correspondingly lower following injection of $PuO_2(NO_3)_2$. On the thirtieth day following intravenous injection there were no significant differences in either urinary or fecal excretion of plutonium administered as $PuCl_3$, $Pu(NO_3)_4$, Pu^{+4} citrate complex, and $PuO_2(NO_3)_2$. At this time the average urinary excretion was 0.014 per cent of the injected dose and the average fecal excretion was 0.22 per cent. The average ratio of fecal to urinary excretion was 16/1.

The skeleton was a major site of deposition regardless of the form in which the plutonium was injected. Four days following injection of plutonium as $PuCl_3$, $Pu(NO_3)_4$, Pu^{+4} citrate complex, and $PuO_2(NO_3)_2$ skeletal deposition was 44.9, 29.3, 56.9 and 56.5 per cent of the injected dose respectively. Deposition in the liver under the above conditions was 22.9, 39.7, 9.6, and 9.1 per cent of the injected dose respectively. Deposition of plutonium in kidney, spleen, and in "balance" was not greatly affected by the form in which the plutonium was administered.

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MDDC - 719 Metabolism of Plutonium, by W. Langham, et al., n.d., decl. 2/18/47 (LADC-222) 22p. (See also The Journal of Biological Chemistry, Vol. 171, p. 273-283, November 1947). (Cont'd from page 460).

The size of the injected dose of Pu^{+4} citrate complex did not affect the per cent of the dose excreted in the feces and urine. Likewise, the size of dose did not alter the per cent of injected material present in the various tissues six days following injection.

Absorption of plutonium from the gastro-intestinal tract was quite low — 0.01% of the administered dose. When Pu^{+4} was administered orally in 5 per cent sodium citrate solution, the presence of the citrate seemed to increase absorption of the plutonium from the gastro-intestinal tract. Absorption was still quite low — only 0.3 per cent of the administered dose.

Seventy-nine per cent of the plutonium absorbed from the gastro-intestinal tract was deposited in the skeleton and 7.3 per cent in the liver. Plutonium absorbed slowly via this route seems to give a higher deposition in the skeleton than it does when administered intravenously as $PuCl_3$, $Pu(NO_3)_4$, Pu^{+4} citrate complex or $PuO_2(NO_3)_2$.

Results are tabulated and graphed.

MDDC - 720 Oscillograph Picture, Los Alamos, 1 p., n.d., decl. 12/16/46. (LADC-312).

Photograph of an unidentified, untitled trace.

MDDC - 721 Physical Properties and Crystal Structure of Polonium, by C. R. Maxwell, 50 p., August 30, 1946. (LADC-284).

Measurements of the physical properties, and crystal structure of polonium show that the element is very metallic. Measurements of the electrical resistivity of thin films of metal show that polonium exists in two allotropic forms. The specific resistivity and thermal coefficient of resistivity of the two phases are respectively:

R_0 - α Po = 42 micro-ohm-cm α -αPo = .0046

R_0 - β Po = 44 " α -β Po = .0070

The element has a melting point of 254°C and a density of 9.4 g/cc. Its hardness is similar to that of lead.

X-ray diffraction studies have shown that α- Po has a simple cubic structure with a lattice parameter "a"= 3.34 Å. The β-phase has a simple rhombohedral structure with "a" = 3.36 Å and α = 98° 13.

A sample which was photographed intermittently for 138 days - the half life of Po — has shown no new diffraction patterns, thus indicating that lead is soluble in polonium to the extent of 50 atomic percent.

Diffraction patterns taken with the sample of different temperatures show that α-polonium has a negative thermal coefficient of expansion equal to $300 \pm 100 \times 10^{-6}$ cm/cm/°C. The coefficient of expansion for β-polonium is probably 50×10^{-6}.

It is concluded that polonium crystallizes with metallic bonding but that the atom is probably incompletely ionized.

Observations on the transformation temperature show that the transition occurs between 65°C and 130°C and that the range depends upon the thickness of the sample used in the determination.

MDDC - 722 Report on Gamma Rays of 77 h Tellurium in Equilibrium with its Products and on 30 d + 200 d Ruthenium in Equilibrium with its Products, by A. C. G. Mitchell, 2 p., n.d., decl. 1/3/47.

Using the technique of measuring the range of Compton electrons as described in MDDC-434, gamma ray measurements were made with coincidence counting apparatus. Results follow.

30d and 200d Ruthenium. The 30d Ruthenium is supposed to have a short-lived Rhodium daughter which emits high energy electrons and gamma rays. A complete curve of coincidences vs. thickness of aluminum from a total stopping power of 1.50 gm/cm^2 to 0.15 gm/cm^2 was run. The range of the Compton electrons was 0.706 gm/cm^2 which from the curve of Curran, Dee and Petrilzka gives 1.5 MV for the energy of the most energetic gamma ray. The number of gm/cm^2 necessary to reduce the coincidence rate to one-half (0.130 gm/cm^2) and to one quarter (0.190 gm/cm^2) were determined and, applying the usual formula, the gamma ray energy was determined as 1.42 MV (at one-quarter intensity) and 1.24 MV (at one-half intensity). Since the extrapolation is a long one the latter figures only serve as an indication that there are lower energy gamma rays present in addition to the one at 1.5 MV.

77h Tellurium. The 77h Tellurium was in equilibrium with its 2.4 h iodine daughter. The range of the Compton electrons was 0.755 gm/cm^2 corresponding to a gamma ray of 1.7 MV.. The extrapolation to zero thickness is again of doubtful significance, but shows the presence of a lower energy gamma ray.

In addition, routine gamma-gamma coincidences were run on the source. The number of gamma-gamma coincidences per thousand gamma ray counts was 0.348. This shows that there is certainly more than one gamma ray per disintegration, presumably from the iodine daughter which emits the 1.5 MV gamma ray.

MDDC - 723 Least Squares Applied to Uranium Decay, by E. D. Nering, 9 p., n.d., decl. 1/8/47.

This application of the Least Squares Method is that of curve fitting. One can fit a curve with given characteristics to a set of points such that the sum of the squares of the deviations of the given points from the curve will be a minimum. This does not mean getting the best possible curve, but only the best curve with these given characteristics.

The method of least squares is something like an average or mean. The only difference is that time enters in an important way.

Mathematical treatment is described and computation made for uranium decay.

MDDC - 724 The Purification of Some Laboratory Gases, by A. S. Newton, 15 p., n.d., decl. 1/24/47.

The purification of the noble gases, nitrogen, hydrogen chloride and hydrogen bromide is described. The preparation of pure hydrogen and deuterium by the decomposition of uranium hydride and uranium deuteride respectively is described. The noble gases are purified using uranium metal as a scavenger for the active gases, nitrogen by using uranium nitride to remove oxygen, and hydrogen chloride and hydrogen bromide by using uranium trichloride and uranium tribromide respectively as purifying agents.

MDDC - 725 The Use of Hearing-Aid Type Tubes in Portable Counting-Rate Meters and Amplifiers, by L. Nierman, 10 p., June 23, 1945. (CP—2854)

The purpose of this report is to make available the general results of development work done on portable counting-rate meters used with proportional counters; such portable instruments have hitherto been comparatively impractical because of the excessive weight of the electronic equipment. By adaptation of standard circuits to the low-power tubes used in hearing-aids and incorporation of components now available, a great reduction in size and weight has been achieved. This general report will be followed by detailed reports on specific instruments using the circuits and materials described here.

A six tube proportional amplifier and counting-rate meter is discussed in detail from a schematic diagram.

The amplifier consists of a pair of degenerative two-stage amplifiers. The overall gain of the amplifier, from grid of the input stage to grid of the pulse-height selector, is a little less than 200. In frequency response, the amplifier is flat to well beyond 200 kc., thus providing sufficient pulse discrimination for the separation of an alpha pulse-height distribution from an intense beta pulse-height distribution.

This six tube model was built into a 6 inch cubical chassis and the unit with A batteries weighs $6\frac{1}{2}$ pounds. A lighter and simpler four tube unit weighing less than three pounds was also built.

This amplifier is a two-stage resistance-coupled non-degenerative design. To discriminate against pickup and microphonics the grid and screen circuit time constants are such as to produce an amplifier with no flat region in its frequency response curve, which reaches a maximum in the vicinity of 12,000 cycles, where the gain is about 400, and is down to 0.707 of its peak value at 4500 cycles and 35,000 cycles.

MDDC - 726 Carbon 14 Production from Ammonium Nitrate Solution in the Chain-Reacting Pile, by L. D. Norris and Arthur H. Snell, 8 p., n.d., decl.1/3/47. (See also Science 105, p. 265-267, 1947.)

Irradiation of solution of NH_4NO_3 by slow neutrons causes the reaction, N^{14} (n,p) C^{14} to take place. The resulting $C^{14}O_2$ from this reaction is separated from the solution and passed through an absorption train which consecutively dries, oxidizes, and finally absorbs the $C^{14}O_2$ in $Ba(OH)_2$ solution. The reaction scale was such that the gas stream ran at the rate of 15 cc/min. Efficiency of the extension chain was found to be 99%. No C^{14} was present in the form of the CN radical and only 1% was present as HCOOH, CH_3OH, and HCHO. The richest samples yielded by this method have isotopic concentrations of about 9%.

MDDC - 727 Microvolumetric Assay of Uranium by L. P. Pepkowitz. 11 p.,December 3, 1945. (LADC-217).

A microvolumetric assay procedure for uranium is presented. Uranium as the +6 sulfate is reduced to the +4 valence state by means of liquid zinc-analgam in a special titration cup. The +4 uranium is then titrated with standard ceric sulfate using a micro-weight burette. The end point is determined by using orthophenanthroline-ferrous complex as an indicator.

MDDC - 728 Preparation of Compacts of High-Density Uranium Hydride, by M. L. Perlman and S. L. Weissman. 6 p., October 16, 1943. (LADC-262).

Compacts of uranium hydride having a density of about 10 or more were prepared by allowing hydrogen to react with uranium metal which is enclosed in a strong steel vessel. The results of several experiments are given and further work on the problem was planned.

MDDC - 729 University of California Synchrotron Drawings, by Radiation Laboratory, University of California, 8 p., n.d., decl. 3/6/37.

Seven drawings of the University of California Radiation Laboratory Synchrotron are inclosed.

MDDC - 730 Internal Cyclotron Targets, by A. F. Reid. 12 p., August 15, 1946. (A-775).

Preparation of cyclotron targets to be used within the dee enclosure for the production of radioelements is discussed from both the theoretical and the application angles. Both general and quantitative considerations are advanced in target design. A table is given representing reaction elements, their target, and percent efficiency.

MDDC - 731 Neutron Yields of Several Light Elements Bombarded with Polonium Alpha Particles, by J. H. Roberts. 24 p.,n.d.,decl. 1/7/47.

Measurements on the thick target yield for (α,n) reactions among the light elements for the alpha particles of polonium have been made. Corrections were supplied for the angular distribution and straggling in energy due to absorption in the source. Neutrons were detected with boron trifluoride proportional counters in a paraffin geometry. The position of the counters was selected so that their efficiency would be fairly independent of the energy spectrum of the emitted neutrons. Standardized Ra + Be and Ra + B sources were used to determine the efficiency of the counters as slow neutron detectors in the paraffin geometry.

The Q values and the maximum neutron energies for each isotope involved were calculated from the isotopic masses. The atomic cross-sections were estimated for alpha particles of energy 5.3 Mev on the assumption that the cross-section is proportional to the Gamow-Condon-Gurney penetration function. It is known in many cases that the cross-section continues to increase after the height of the potential barrier has been reached. In most cases these estimates will therefore be low but of the correct order of magnitude. For beryllium, the cross-section was calculated on the basis of its excitation function.

MDDC - 732 New Radio Isotope of Tantalum Produced by Slow Neutron Irradiation, by L.Seren, H. N. Friedlander, and S. Turkel, 16p., n. d., decl. 2/3/47

A new radioactive period of tantalum was discovered by irradiating tantalum with thermal neutrons in the thermal column of the Argonne heavy water pile. The new period is 16 2 ± 0.5 minutes and is produced in addition to the well known 100 day $_{73}Ta^{182}$

The new 16 2 minute activity was shown to be a tantalum isotope because:

1) Very pure (99.9%) tantalum foil gave this activity when irradiated with only slow neutrons.
2) No other element gives a known 16.2 minute activity with slow neutrons, hence it is unlikely that the observed activity was due to an impurity.
3) Finally the element was confirmed as Ta by chemical separations using a soluble salt, $(NH_4)_2TaF_7$. That the 16.2-minute activity does not grow from the 117-day activity was shown by a very short irradiation (5 minutes) in which no growth of the 16.2-minute activity was observed. The atomic cross section for thermal neutrons for the 117-day activity (20.6 barns) is of the order 1000 times greater than the (0.034 barns) for the 16.2-minute activity. These cross sections assume that both activities emit beta particle. The range of the 16.2-minute activity particles is ~ 50 mgm/cm^2 aluminum and a gamma- or X-ray is also present.

MDDC - 733 The Reaction $_{38}Sr^{86}$ (n,gamma) $_{38}Sr^{87*}$ Produced by Thermal Neutrons, by L. Seren, H. N. Friedlander, and S. Turkel, 3 p., n.d., decl. 2/3/47. (See also Physical Review Vol. 71, p. 454, April 1, 1947.)

The 2.7h isotope $_{38}Sr^{87*}$, which is the excited isomer of the stable state $_{38}Sr^{87}$, was produced by irradiating $Sr(NO_3)_2$ with thermal neutrons in the Argonne pile. This is the only radioactive isotope produced by thermal neutron capture of stable isotopes ($_{38}Sr^{86}$) in which the binding energy released by capture produces on excited state of the next stable isotope. $_{38}Sr^{87*}$ has previously been produced by fast neutrons on Sr by the reaction $_{38}Sr^{87}$ (n,n) $_{38}Sr^{87*}$. With an internal conversion coefficient of 15%, the cross section per Sr atom for this thermal neutron reaction is 0.13 barns.

MDDC - 734 A Slide Rule for Activation and Decay Calculations, by A. H. Snell and T. Arnette, 7 p., May 6. 1946.

The calculation of the strength of radioactive samples after neutron irradiation, followed perhaps by a period of decay, has become so much a matter of routine that it seems that a quick aid to calculation might be a time saver to those engaged in this type of work This document shows how a slide rule could be constructed which would give answers to these calculations, including in most cases the correct power of ten, to an accuracy commensurate with the precision of most cross section and flux values.

Diagrams are included as well as sample calculations.

MDDC - 735 Measurement of Neutron Cross Sections with a Crystal Spectrometer. by W. J. Sturm, 42 p., n.d., decl. 1/27/47. (See also Physical Review, Vol. 71, p. 757-776, June 1, 1947.)

Employing the monoenergetic beams of neutrons diffracted from the (100) planes of lithium fluoride, survey measurements of the total neutron cross section of a series of elements were made. The strong diffracted beams were obtained by placing a single crystal in the high flux of neutrons emitted by the heavy water moderated pile at the Argonne Laboratory. Observations on this group of elements, which includes several strongly absorbing rare earths, and elements commonly used as neutron filters and detectors, were made in the range of energy between 0 04 and 65.0 electron volts. The method permits energy dependent cross section measurements by activation or by transmission. However all values reported were obtained by calculation from observed transmission data because the range of available intensities in the diffracted beam was best measured with a boron counter. Correction methods for resolution and order effects were developed which are valid for low neutron energies. The following absorption levels were observed: Rh, 1.28 ev; Au, 5.4 ev; Ir, 0.635, 1.35, and 6.0 ev; Gd, 0 31 ev; Sm, 0.096, 10.0, and 33.0 ev; Eu, 0.465, 3.3, 9.2, and 22.0 ev. Resonance levels at energy less than zero were found in Dy at -1.01 ev and in Eu at -0.011 ev.

MDDC - 736 The Total Neutron Cross Section of Dysprosium and Neodymium, by W. J. Sturm and G. Arnold, 5 p.,n.d., decl. 3/2/47. (See also Physical Review Vol. 71, p. 556-557, April 15, 1947).

Considerable improvement in the performance of neutron monochromators is achieved by reflecting from the (111) plane of LiF, as compared to the previously employed (100) plane of LiF. For neutron energies of about .04 ev the first order intensity is enchanced and the higher orders greatly suppressed in the new arrangement, as compared to the old. Preliminary measurements made on the above elements indicate the presence of resonance levels in dysprosium at 1.74 and 5.5 Mev, some evidence for a level at negative energy, and a level at an energy higher than 20 ev. For the case of neodymium a plot of cross section x neutron velocity against energy shows a monotonic rise with energy, indicating a possible strong resonance level at higher energy.

MDDC - 737 Cross Sections by the Be^7 and Mn-Bath Methods, by R. F. Taschek and C. M. Turner, 19 p., November 3, 1945. (LADC-298).

A method is described which has been used to measure the energy dependence of the ratio of neutron reaction cross sections. The method involves the monitoring of total neutron flux by either a Mn bath or the radioactivity of Be^7 for the special case of the Li(p,n) source; for the latter it is also possible to make a special measurement at a neutron energy of 30 kev by utilizing the momentum properties of the source. Diagrams of the bath are included.

MDDC - 738 Thermal Diffusion with Boron Trifluoride, by W. W. Watson, 9 p., n.d., decl. 2/25/47. (See also Physical Review, Vol. 71, p. 887-890, June 15, 1947.)

Boron of mass 10 is of considerable interest in nuclear research because of its large cross-section for the $B^{10}(n,\alpha)Li^7$ reaction. To increase the concentration of this isotope in some boron compound, it seemed possible that the thermal diffusion method, which has been so successful in numerous isotope separation experiments, would serve. The only available gaseous compound stable over a sufficiently large temperature range is boron trifluoride.

With BF_3 gas at atmospheric pressure in 7 meters of hot-wire Clusius and Dickel columns with $\Delta T=400^oC$ the equilibrium separation factor for $B^{10}F_3/B^{11}F_3$ was 1.32 ± 0.12, reached in slightly over three days. The best separation factor per meter of column indicates a thermal diffusion constant $\alpha \simeq 5.0 \times 10^{-4}$ and $R_T \simeq 0.06$. Experience in purifying commercial BF_3 gas and with mass spectrometer analyses is discussed.

Concentrated B^{10} material can be obtained by the thermal diffusion method, but with an over-all efficiency of the plant much too low to make it attractive.

MDDC - 739 Electronic Circuits - II, by R. J. Watts, 38 p., November 1944. (LADC-129).

Drawings for the following are assembled: Safety circuit, power supply for D. C. amplifier, D. C. amplifier for safety circuit, bias battery chassis for safety circuit, scaler unit circuit model scaler unit -- schematic, scaler unit plate, model 100 precision pulser - front panel-chassis, coincidence analyzer calibrating chassis, temperature control electronic relay, model 100 preamp wiring layout, valve control, sliding pulses, sliding pulser panel outlay-chassis outlay, sweep circuit panel layout-chassis layout, model 50 power supply chassis layout-panel layout, model 50 power supply chassis layout 2-microsecond-pip generator-mark III, 5 micro-second pip generator mark II panel layout-chassis layout, model 600 ion gauge chassis layout-panel layout, integrator circuit, model 100 precision pulser layout for sloping front cab, model 100 pulser cable and attenuators, instructions for model 100 pulser, model 220 counter test unit chassis layout and panel layout R. C., model 300 amplitude analyzer, chassis layout for model 411 scaler.

MDDC - 740 Electronics Circuits - III, 12 p., May 1945. (LADC-139)

Drawings are presented as follows: chassis layout and panel layout — Model 300 pulser, chassis layout and panel layout — Model 300 sweep, triggered gate circuit, multiple trigger delay circuit, panel layout — and resistor brackets for Model 411 scaler, mounting strips.

MDDC - 741 Electronic Circuits - IV, by R. J. Watts, 20 p., January 1, 29, 1945. (LADC-195).

Drawings for the following are included: revised coincidence circuit; model 600 ion gage (for oscilloscope); panel layout for mounting bracket; dual low voltage supply for oscilloscope; model 100 ion gage control chassis layout and panel layout; counter chronograph — parts A and B, respectively; counter chronograph part C — power supply, 200 sec precision delay unit, 2, 5 and 10 sec. marker generator; chronograph calibrator, 1500 R. F. power supply; precision pulser model 50 (for calibrating discriminator); nomograph for R. C. coupled and single tuned I F. amplifier; nomograph for shunt — compensated amplifier, $L = 1/4\ R^2\ C$ also one for $L = 0.414R^2C$; model 220 counter test unit power supply, and panel layout; constant current supply for magnet; pippertron; frequency deviation meter.

MDDC - 742 Metaborate Compounds for Internal Cyclotron Targets, by A. S. Weil, J. R. Dunning, Jr., and A. F. Reid, 11 p., October 4, 1946. (A-3855) (See also the Review of Scientific Instruments, Vol. 18, p. 556, August 1947.)

The use of $NaBO_2$ as a target material for the preparation of radioactive Na^{24} through the deuteron bombardment reaction

$$_{11}Na^{23} + {}_1d^2 \longrightarrow {}_{11}Na^{24} + {}_1p^1$$

is discussed. The general advantages of $NaBO_2$ as a target material, compared to metallic sodium or other sodium containing compounds, are given; as well as the procedure for target preparation and the details of the chemical treatment used for the purification of the Na^{24}.

The general use of metaborate targets is discussed briefly for other deuteron bombardment reactions in which an elementary target material is less practical to use.

MDDC - 743 Introduction, by A. M. Weinberg and E. P. Wigner, 2 p., n.d., decl. 12/31/46.

The decision to construct the nuclear chain reacting piles at Hanford with a cylindrical lattice of uranium rods imbedded in graphite moderator was dictated primarily by engineering considerations. It is evidently more convenient to cool a rod with a flowing film of water than it is a sphere or a plane. Once this decision was made, it meant that all theoretical calculations of the multiplicative properties of the system, the neutron distributions, and so on, involved cylinder functions.

The computation of the fraction of neutrons absorbed in a uranium rod imbedded, as part of a lattice, in a graphite moderator, is a problem in elementary diffusion theory. The solution in the rod is a Bessel function of zeroth order of the first kind, $I_0(\kappa_0 r)$; the solution in the graphite is a linear combination of both $I_0(\kappa_1 r)$ and $K_0(\kappa_1 r)$. The quantities κ_0 and κ_1 are the reciprocals of the so-called diffusion lengths in the uranium and in the graphite, respectively; they are a measure of how strongly slow neutrons are absorbed in the medium. In the graphite moderator, κ_1 must be a very small number, since otherwise the neutron absorption in it would be too large to allow the neutrons to diffuse into the uranium.

The value of $\kappa_1 r$ for which the neutron density is required in the graphite is often less than 0.5. In this range the British Association Tables of $K_0(x)$ and $K_1(x)$ are rather inaccurate, since both functions are singular at $x = 0$. In order to avoid the necessity for laborious interpolation in the B A. Tables when neutron distributions in graphite were needed, it was felt advisable to have a table of the functions $K_0(x)$ and $K_1(x)$ for those small values of x which, while not contained adequately in the British Tables, are very often used in neutron computations.

The tables of $Y_0(x)$ and $Y_1(x)$ for small arguments were required also for problems connected with the design of the chain reacting units.

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MDDC - 743 Introduction, by A. M. Weinberg and E. P. Wigner, 2 p., n.d., decl. 12/31/46. (Cont'd from page 473).

This paper is therefore an introduction to a collection of tables of Bessel functions prepared by the computing section of the Department of Commerce.

MDDC - 744 A Mathematical Foundation of the Resonance Theory, by E. P. Wigner and L. Eisenbud, 4 p., January 15, 1947. (MonP-238).

A mathematical derivation which can account for resonance phenomena is given. The physical applications of the derivation refer to the collision of particles. (See also MDDC-1612).

MDDC - 745 Stability of a Fin in Boiling Liquid, by G. Young, 9 p., January 26, 1945. (CP-1902).

An idealized discussion of heat transfer in boiling is given, and some calculations of fin performance are made. It is found that infinitely long fins impart stability to a surface being cooled by a boiling liquid.

MDDC - 746 Assembly of Thin Wall Geiger Counter, by Argonne National Laboratory, 5 p., n.d., decl. 1/22/47.

The document consists of three photographs and two drawings showing the parts and assembly of a thin wall Geiger counter.

MDDC - 747 Neutron Temperature Measurement in Graphite and in Uranium-Graphite Reactor, by G. M. Branch, 23 p., October 4, 1946. (MonP-182).

The temperature of neutrons at thermal equilibrium in graphite and in the Clinton uranium-graphite pile has been measured by observing the transmission of the neutrons through calibrated 1/v absorbers, as detected by 1/v detecting foils sandwiched between an identical pair of the absorbers. On the assumptions that the neutron velocity distribution is approximately Maxwellian and that the neutrons are scattered isotropically in the moderator, the following expression is derived for the relationship between the transmission, A/A_o, and the most probable velocity of the neutrons, α;

$$A/A_o = 4/\sqrt{\pi} \int_0^\infty x^2 \; e^{-x^2} \; E_2 \; (v_a/\alpha x) \, dx,$$

where $E_2(v_a/\alpha x)$ is an E function tabulated by Placzek in MT-1 and v_a is a measurable absorber constant defined by the relation

$$v_a = - v \ln (I/I_o),$$

I/I_o being the transmission of a parallel beam of monoenergetic neutrons of velocity v through the absorber.

The neutron temperature in a large block of graphite was measured to be about 80^o K above the graphite temperature, in the uranium-graphite reactor about 140^o K above the graphite temperature.

MDDC - 748 Slowing Down of Neutrons, by G. Breit, 70 p., August 18, 1941 (A-27)

The Boltzmann equation expressing conservation of particles in phase space is set up and special solution of it, referred to as "characteristic functions" are worked out. These are compared with corresponding results following from the diffusion equation by plotting the real power of the velocity which corresponds to a given wave number β in the factor $e^{-i\beta 2}$ representing the variation of intensity with distance against $1/\beta\lambda$ and $\beta^2\lambda 2$ where λ is the mean free path for scattering.

A solution for neutron density is expressed in the form of a Fourier integral. The Fourier coefficients are worked out explicitly and an asymptotic form for the coefficients applicable to large amounts of slowing-down is found.

(Qex), the number of neutrons crossing a given energy per cm^3 per second is expressed in terms of the neutron density per unit velocity range, and an approximation to (qex), called (q), which is simpler to determine experimentally, is derived.

Integrals over products of powers of v and the neutrons density are expressed in the form of Fourier integrals, and the results compared with the approximate ones obtained form the diffusion equation.

The space distribution of neutrons having different energies is worked out for the case of sources distributed on a plane, where scattering is assumed to be spherically symmetric in the center of mass system of the neutron and the slowing-down nucleus.

MDDC - 749 The + 5 Oxidation State of Plutonium, by R. E. Connick, M. Kasha, W. H. McVey, and G. E. Sheline, 25 p., July 31, 1946.

It is shown that the + 5 oxidation state of plutonium exists in aqueous solutions. Pu(V) can be produced by chemical or electrolytic reduction of Pu(VI) but is thermodynamically unstable in 0.5 N HCl solution. Values are given for the potentials relating Pu(V) to the other oxidation states of plutonium. The absorption spectrum of Pu(V) in 0.5 N HCl is shown.

MDDC - 750 The Transmission of Radio-Strontium and Plutonium from Mother to Offspring in Laboratory Animals, by M. P. Finkle, 41 p., January 28, 1947. (See also Physiological Zoology, Vol. 20, p. 405-421, 1947).

Fetal rats and mice were treated with radio-strontium and plutonium by injecting their mothers with the materials either before conception or during pregnancy. A low incidence of pregnancy and an increased number of stillbirths were observed. The amount of radio-strontium retained by the mothers immediately after parturition was the same as that retained by the virgin adult females at comparable time intervals; a portion of the material that would ordinarily have been excreted was lost through the placenta. The percentage of the maternal dose that was found in the young at birth varied with the injection-delivery interval. The strontium activity per gram of body weight of the new born exceeded that of the mother at the same time of delivery if parturition occurred within the first four days after administration. At the plutonium levels studied, the specific activity of the young at birth never exceeded 8 per cent of the specific activity of the mother. Treatment of the young animals was continued during the period of suckling by the transfer of both plutonium and radio-strontium through the breast milk. The majority of the animals that received the materials before weaning, are still living and only a preliminary note on their progress is given. The animals of the strontium series have shown retardation of growth, malformation of the long bones, anemia, and osteogenic sarcoma. The animals of the plutonium series have developed no pathologic conditions to date. At the present state of these experiments there was no indication that fetal and very young tissues are either more or less sensitive to radio-strontium and plutonium than are adult tissues.

MDDC - 751 Analytical Chemistry of the Manhattan Project - Chapter VII - Photometric Methods, by M. Fred and C. J. Rodden, 33p., decl. 2/26/47.

Spectrophotometric and colorimetric methods of analyses have been very widely used on the Project for the determination of elements in solution in the form of dissolved highly-colored compounds or complexes. Infrared spectrophotometry has been used for the analysis of hydrocarbons and fluorocarbons and for measuring the concentration of fluorocarbon in air and uranium hexafluoride. Spectrophotometric methods using the visible and ultraviolet region of the spectrum have been employed in various applications such as the determination of oxidation states or the analysis of organic materials.

Photoelectric colorimeters have been made for the determination of traces of UF_6 in air. Gaseous UCl_4 has been determined by methods using its absorption of ultra violet radiation.

Fluorescence methods with accompanying photoelectric measuring instruments have been investigated on the Project and applied to the determination of traces of uranium and fluoride.

MDDC - 752 Analytical Chemistry of the Manhattan Project - Chapter IX - Spectrochemical Methods, by M. Fred and B. F. Scribner, 40 p., n.d., decl. 2/26/47.

This chapter consists of a general discussion of spectrochemical methods, describing the fundamental principles on which they are based, indicating the reasons for the adoption of each method, and comparing their effectiveness for different problems.

Spectrochemical methods of analysis provide for the detection and determination of chemical elements in materials by observation of their emission spectra. Each of the chemical elements can be caused to emit a characteristic spectrum and consequently each is capable of determination although the ease of observation varies considerably among the individual elements. By convenient procedures, involving arc and spark excitation, 70 elements may be detected at low concentrations in a wide variety of materials. The remainder of the elements, mostly gases and metalloids require special procedures for their observation and, generally no advantage is offered for the determination of these elements over estabilished chemical methods. Applications of spectrochemical methods to quantitative analysis have been a compartively recent development resulting from refinements attained in spectral excitation, photography and photometry in the past quarter-century.

The minimum detectable amount of an element is 100 to 1,000 times greater for the porous graphite method (solution absorbed in a porous graphite electrode and then vaporized in a spark) than for the copper spark method, so that the sensitivity is of the order of conventional d-c or a-c arc sources. The advantages over the latter are greater accuracy and less interference from variations in the composition of the sample.

MDDC - 753 An Investigation of the β Ray Spectrum of 93^{239}, by H. W. Fulbright, 40 p., May 1944. (CP-1727 [A-2441]).

A description of the spectrograph used and experimental methods are given.

Briefly the results of measurements on the decay of 93^{239} are summarized as follows:

Continuous β Spectrum. Upper energy limit of about 0.70 Mev.

γ rays. Various conversion lines indicating γ's with energies up to 277.4 Kev are found. Of these γ's those of energies 209.4, 228.0 and 277.4 are outstanding. Only very weak γ's of higher energy are admitted by results of absorption measurements made in a pure Np^{239} sample.

94^{239} nuclear energy levels. Energy level diagram uncertain and complicated.

Tables, drawings and graphs are included.

MDDC - 754 Effects of Periodic Doses of Slow Neutrons on Mice, by P. S. Henshaw, et al., 12 p., August 27, 1946. (MonH-118).

Periodic doses of a radiation designated as "slow neutron" were given to two groups of 100 CF-1 female mice. Each arbitrary unit of dose, expressed in a, was composed of slow neutrons considerably contaminated with fast neutrons. The mice were exposed in a manner similar to that used for fast neutron exposures, but in the cart designed specifically for "slow neutron" irradiation. The results are very similar to those observed as a consequence of periodic fast neutron treatments. A comparison of the shortening of life induced by each radiation indicates that 1 n is as effective as 7.5 a, a ratio roughly equivalent to that observed after single doses. A dose of 10 a per day depressed the leukocyte level to a range between 2000 and 3000 cells/mm^3 more pronounced blood changes probably would have been noted had other strains been used. The terminal pathological condition of the experimental mice was essentially like that observed after periodic fast neutron or gamma ray irradiation.

MDDC - 755 Analytical Chemistry of the Manhattan Project, Chapter XXIX, Zinc, Cadmium and Mercury, by K. J. Jensen, 18 p., n.d., decl. 2/26/47.

The estimation of zinc and cadmium, particularly the latter, was of very frequent occurrence in connection with a great variety of materials that were used throughout the Project. The determination of mercury was frequently called for because of the hazard to health that accompanied its use in various equipment.

No novel methods were developed for the macro determination of zinc. In addition to the customary macro methods such as the precipitation of the double phosphate, the ferrocyanide titration, deposition in a mercury cathode and precipitation as the sulfide, further study was given to the use of organic reagents such as 8-hydroxyquinoline, diethyldithiocarbamate and 8-hydroxyquinaldine. Electrolytic deposition of zinc was used for zinc-thorium alloys. The chief interest was in the estimation of traces of zinc in uranium or the raw materials and intermediates that were used in its preparation. The dithizone extraction method was much used as were a combination of electrolysis and polarography. The spectrographic method using carrier-distillation technique was of considerable service.

Interest was centered in distinctive compounds and in methods of separation that might be used in the estimation of traces of cadmium. Certain complex ions containing cadmium are precipitated by organic bases. For example, CdI_4^{2} is precipitated by bases such as brucine and 8-naphthoquinoline. The extraction of cadmium with dithizone and carbon tetrachloride was widely used.

The chief interest in Project work on mercury was in the determination of traces of it. The colorimetric method using dithizone depends upon the fact that mercury is extracted as the salmon colored complex with dithizone and chloroform. The determination of mercury vapor in air is best made by measuring the absorption of radiation at 253.7 mμ. The method used was based upon the formation of increasingly intense colored precipitates when mercury iodide is precipitated upon a white cuprous iodide matrix.

MDDC - 756 Drawings on an Electrolysis Assembly, by Robert Loevinger, 13 p., n.d., decl. 1/12/47.

This document consists of two photographs and ten drawings of an electrolysis assembly for electroplating radioactive samples and one drawing of a thin-window Beta-counter. Included are a cell support, an electrolysis cell, electrolysis cell cathode, cell rack, Geiger counter absorber slide, carrier for electrolysis cell cathodes, and a cover for electrolysis cell cathode carrier.

MDDC - 757 Tissue Metabolism of Rats Treated with Uranyl Nitrate, by J. Meyer et. al. 16 p., January 22, 1947. (CH-3710)

In rats, toxicity of injected uranyl nitrate can be easily detected by measuring the blood NPN. As little as 0.1 mg per kg was enough to produce a definite rise four days after injection. Definite symptons of intoxication were produced by 0.5 mg per kg, the blood NPN rising about 3.5 times above the normal values On injection of 0.5 mg per kg, the metabolism of kidney slices, as measured by the oxidation of pyruvate, succinate, and alanine, was progressively inhibited from the second day after injection. The synthesis of carbohydrate in the presence of pyruvate was also inhibited. Anaerobic glycolysis and choline oxidation were unaffected. The oxygen uptake of the liver was unaffected. There was a slight inhibition of pyruvate utilization. The synthesis of urea and the synthesis of glycogen were inhibited.

MDDC - 758 High-Temperature Heat Contents of Uranium, Uranium Dioxide, and Uranium Trioxide, by G. E. Moore and K. K. Kelley, 9 p., n.d., decl. 2/21/47.

High-temperature heat contents of uranium, uranium dioxide, and uranium trioxide were measured from 298.16°K. to 1,300°K., and 900°K., respectively.

Uranium undergoes two sharp transitions, at 935° ± 3°K, and 1,045° ± 3°K. The heats of transition are 680 and 1,165 cal./g.at., respectively.

Equations representing the experimental results were derived and a table of heat content and entropy increments above 298.16°K. was compiled.

MDDC - 759 Effect of Uranium on the Metabolism of Yeast and Bacteria by J. A. Muntz, et al, 32 p., January 27, 1946. (CH-3716)

The utilization of glucose (fermentation or oxidation) by living yeast cells was found to be extraordinarily sensitive to uranium under the proper conditions. The inhibitory effect was readily reversed by phosphate and bicarbonate, quite unlike the inhibitory effect of the metal on isolated enzymes. The emzymes responsible for carbohydrate metabolism in yeast, when obtained in cell free juice, were also inhibited by uranium but this inhibition was not readily relieved by phosphate.

This suggests that the toxic effect of the metal on these cells is brought about by a different mechanism than is the uranium inhibition on isolated enzymes which are sensitive to the metal. Different kinds of bacterial cells showed varying degrees of sensitivity to uranium. In all cases studied, phosphate relieved any inhibitory effect produced by uranium. The suggestion was made that uranium combines with certain accessory groups present on the cell surface and necessary for glucose utilization.

Charts and graphs illustrate the results.

MDDC - 760 The Transport of Uranium to the Tissues. Some Properties of Uranium in Solutions and in Combinations with Proteins, by J. A. Muntz and E. S. G. Barron, 28 p., January 21, 1947. (CH-3708).

With the aid of a rapid method of ultrafiltration it has been found that uranyl nitrate in aqueous solutions diffuses readily. When the pH of the solution was increased so that the uranium was present as a negatively charged ion, it could not be ultrafiltered. At pH values within physiological limits, uranium diffused freely in the presence of bicarbonate. At a concentration of bicarbonate of 0.03 M, 75 per cent of the uranium was found in the ultrafiltrate. In the presence of organic compounds the ultrafiltration of uranium seemed to be determined by the degree of association of the complex. Strongly associated complexes, such as maleate at pH 6.5, diffused freely through the cellophane membrane. Addition of serum albumin diminished the amount of diffusible uranium presumably by chemical combination. When uranyl nitrate was added to undialyzed rabbit serum, about 75 per cent of the uranium was found in the ultrafiltrate; when it was added to dialyzed serum all the uranium was retained by the protein or remained as non-diffusible uranyl anion. Combination of uranyl ion with serum protein takes place with the albumin fraction. This has been shown in in vitro experiments with separation of the protein fractions by electrophoresis. For the analysis of uranium, a colorimetric method was used which allowed determinations from 10 to 80 micrograms of uranium.

From these experiments it may be concluded that uranium is transported to the tissues as strongly associated complex compounds, mostly as bicarbonate and protein complexes. Rapid urinary excretion of uranyl nitrate injected into animals must be due to glomerular filtration of the uranyl bicarbonate.

MDDC - 761 Physiological Observations on Rabbits Exposed to Single Doses of X-Rays by E. E. Painter, C. L. Prosser, and M. C. Moore, 61 p., January 29, 1947. (CH-3727)

Most of the acute deaths among rabbits after single total-body X-radiation occur in the first two days or at 10-15 days after irradiation. Signs of clinical depression are seen in survivors of sublethal doses during each of these periods, termed the initial shock period and the principal acute radiation death period.

The femoral arterial blood pressure of unanesthetized rabbits declined rapidly from a control of approximately 98 mm Hg to a minimum of about 50 mm Hg at 1-1/2 hours after doses of 600 r or greater. Proportionately smaller reductions in blood pressure occurred after 400 and 200 r. The threshold for 10-20 mm drop was approximately 50 r. During the first few hours the heart rate increased and rectal temperature rose, although the latter effect was largely due to confinement in treatment boxes.

Survivors of the initial shock period showed partial recovery of blood pressure, but at about 10 days, blood pressure again declined, particularly in rabbits which died acutely. Low blood pressures were not observed at this time after doses of 400 r or less.

Plasma protein concentration declined slightly during the acute post-irradiation period.

Plasma volume as measured by Evans blue space was not significantly altered in the initial shock period after a dose of 800 r.

Intradermally injected dye (Evans blue) spread more rapidly in the irradiated than in non-irradiated skin during the first few hours after irradiation. At the same time intravenously injected dye appeared in the

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MDDC - 761 Physiological Observations on Rabbits Exposed to Single Doses of X-Rays by E. E. Painter, C. L. Prosser and M. C. Moore, 61 p., January 29, 1947. (CH-3727) (Cont'd from page 483).

interstitial space of a patch of irradiated skin much earlier than in non-irradiated skin. At 10-20 days after irradiation, intravenously injected fluorescein appeared within a few seconds in an irradiated area of skin and in several minutes in a non-irradiated area. These results indicate increased flow in skin lymphatics in the first few hours and increased passage out of capillaries in this period as well as during the period of maximum erythema.

During the day following a dose of radiation in the lethal range, rabbits eat less than 20 per cent and drink less than 60 per cent of their normal amounts. Thereafter, food and water consumption increase partially but remain below normal in rabbits which die in the acute period. Recovery in survivors occurs gradually over about a month. Average weight loss is marked (10-15 per cent) in the first three days; weight remains diminished for about one week, after which some rabbits die and others begin a gradual recovery in weight which is not complete by 30 days. Some individual rabbits show two minima in food and water intake and in weight; one, at 1-2 days, and the second, at 10-15 days.

Rabbits show a polyuria on the 2nd to 4th day after receiving 800 r. Thereafter urine output decreases slightly below control values but not as much as water intake decreases.

Non-irradiated rabbits were transfused with 50 ml of blood from irradiated rabbits. Blood removed from rabbits 1-1/2 hours after 800 r caused an average fall of 26.2 mm in arterial blood pressure of the recipients; blood removed 5-12 days after irradiation caused variable but much smaller fall in the pressure of the recipient. Blood from non-irradiated donors had no significant depressant effect.

Histamine analyses of blood and plasma were made by the method of Code. The plasma of non-irradiated rabbits had an average of 0.3μg/ml, while plasma removed about 1-1/2 hour after 800 r contained a mean of 0.6μg/ml. The values for whole blood declined due to removal of cells in subsequent sampling.

MDDC - 762 Gamma and Beta-Energies of Some Radioactive Isotopes as Measured by a Magnetic Lens Beta-Ray Spectrometer by W. Rall and R. G. Wilkinson, 2 p., n.d., decl. 12/31/46. (See also Physical Review Vol. 71, p. 321, March 1, 1947.)

A thin magnetic lens beta-ray spectrometer, was constructed for the purpose of measuring radioactive isotopes produced at the Clinton Pile. The instrument was designed primarily for the study of beta radiations between the energies of 0.1 to 3.0 Mev. The momentum of the focussed electrons is determined by the relation $P = kI$, where I is the current through the lens coil and (k) a constant determined by the dimensions and number of turns of the coil. Since the electron paths are quite complicated no attempt is made to use the spectrometer as an absolute instrument; i.e., (k) is experimentally determined. To determine k the F conversion line of thorium B ($H\rho$=1385) and the photoelectron line due to annihilation radiation from positron emitters (.511 Mev) are used. Agreement between the two calibrations is obtained to about 0.1%. A further check on the linearity of the calculation was made by using photo-electron lines. Half intensity widths are obtained for photo-lines between 4 and 6%, and for conversion lines, between 2 and 4%. Beta and gamma sources as weak as .005 and 0.5 mc respectively, have been successfully used.

The results of most of the investigations are tabulated.

MDDC - 763 An Introduction to Nuclear Chemistry Lecture Series, by G. T. Seaborg, 69 p., May 1942. (CL-440).

Nuclear chemistry embraces the study of nuclear reactions and the study of the methods of radiochemistry. Attention is given to methods of production and of detection and to the techniques of handling small amounts of radioactive material.

Recommended books and articles with brief comments are listed. Topics covered in the lectures are as follows:

1. Fundamental properties of nuclei.
2. Simple nuclear thermodynamics.
3. Types of nuclear reactions.
4. Instruments for the detection of radiation.
5. Artificial radioactivity.
6. Chemical methods of isolation and concentration.
7. Precipitation rules and the chemistry of microscopic quantities.
8. Atom-tagging experiments.
   Stable isotopes and masses.
   Methods of production and yields of radioelements.

MDDC - 764 Photo-Neutrons Produced in D_2O and Beryllium by Fission Product Gamma-Rays, by W. D. B. Spatz, D. J. Hughes and A. Cahn, 9 p., n.d., decl. 4/22/47.

The production of photo-neutrons in deuterium and beryllium by the gamma-rays emitted by fission products of U^{235} was studied. The U^{235} sample was shot from a position near the chain-reacting pile to a tube which was surrounded by a cylinder of deuterium or beryllium.. The neutron energies were determined by standardization of the geometry with neutron sources of known energy. The intensity of photo-neutrons relative to delayed neutrons could be obtained; for deuterium the ratio is 0.28. Separation of photo-neutron from delayed neutron periods of the same order of magnitude is difficult. As a result the high energy short period gamma-rays were measured directly by obtaining absorption coefficients for each period in iron and lead, and the effect of the gamma-rays producing photo-neutrons was calculated The gamma energies calculated from the measured neutron energies are in good agreement with those measured directly. Also the photo-neutron intensities calculated from the gamma intensities are in approximate agreement with the observed intensities.

MDDC - 765 Experiments to Test the Validity of the Linear R-Dose/ Mutation Frequency Reaction in Drosophila at Low Dosage, by W. P Spencer, 68 p , n.d., decl. 3/5/47. (II - 188 - 6524).

Using a tool stock supplied by Dr. H. J. Muller, 200,801 x-chromsomes of mature sperm of a Canton Special stock of Drosophila melanogaster were tested for the origin of new lethal mutations.

Of these chromosomes, 73,901 were controls, 51,907 were subjected to x-rays at a dosage of 25 r, 31,560 at 50 r, 23,195 at 150 r, 6,634 at 500 r, 6,977 at 1000 r, and smaller numbers at 2000 r, 3000 r, 4000 r.

From these tests it is concluded that even for X ray dosages as low as 50 r and 25 r the linear r-dose/mutation frequency relation holds.

From all of the data collected, on the basis of this linear relationship, the control lethal mutation rate in the Canton Special stock tested was calculated as 0.1004% and the induced mutation rate per r as 0.00215%. When only data at dosages of 1000 r and lower were included, the control mutation rate was calculated as 0.1039% and the induced mutation rate per r as 0.00197%.

The present data indicate that the control mutation rate was doubled at an exposure to about 50 r. The apparent discrepancy between this figure and that of 35 r derived from earlier X-ray experiments may be explained on the ground that sperm cells of young males, which Muller has shown give a high control rate, were used exclusively in this experiment.

Several cases of control "lethal clusters" were found, and are interpreted as due to mutations occurring in early stages in the germ tract. The problem of sampling sperm cells is discussed in this connection.

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MDDC - 765 Experiments to Tests the Validity of the Linear R-Dose/Mutation Frequency Reaction in Drosophila at Low Dosage, by W. P. Spencer, 68 p., n.d., decl. 3/5/47. (II-188-6524) (Cont'd from page 486).

The implications of the findings in connection with the exposure of large numbers of the human race to low dosages of X-rays are discussed briefly.

A parallel study of visible mutation rates has given an over-all lethal-visible mutation ratio of 5.2: 1.

The data on visibles are not inconsistent with the view that the linear dosage/mutation relation holds at low dosages for this class of mutations as well as for lethals

Linkage studies on 229 lethals and visibles are reported. Relatively high mutation rates both for lethals and visibles were found in genetic chromosome map regions 0-5, 20-25, and 55-60 and a relatively low rate near 10.

Mutations in control chromosomes and in those subjected to low dosages of X rays were rarely associated with cross-over suppressors, while mutations in chromosomes receiving high radiation were frequently associated with cross-over suppressors.

A discussion of technical problems in connection with large scale mutation rate studies at low dosage is included.

Tables and graphs are given.

MDDC - 766 Counting Rate Meter Based on A Design by M. I. T., by R. L. Sternberg, 13 p. n.d., decl. 12/31/46.

The Counting Rate Meter described was built largely from designs contained in the Massachusetts Institute of Technology report entitled "Improvements in the Counting Rate Meter".

The purpose in building this instrument was to produce a counting rate meter to operate in conjunction with a recording galvanometer (in this case a 5 milliampere Esterline Angus recorder) to indicate and record counting rates of from 50 to 20,000 counts per minute accurate to within 5% for randomly distributed pulses. The range of from 50 to 20,000 counts per minute was accomplished in seven separate ranges. This counting rate meter will be useful in studying radiations from sources having half lives greater than 1 1/4 minutes for ranges 1, 2, and 3 greater than 50 seconds for ranges 4, 5, and 6 greater than 25 seconds for range 7. (The appendix contains a mathematical treatment of this).

To facilitate easy calibration check of the instrument a pulse generator producing pulses at exact multiple and sub-multiple frequencies of 60 cycles per second was included with the Counting Rate Meter.

Although the instrument is designed to count beta and gamma radiations operating from a Geiger-Mueller tube it could be used with a standard chamber and pre-amplifier to count alpha particles.

Calibration curves of the "Counts per Minute" meter are included in the appendix at the end of the report. The curves are plotted to show the calibration for both random and periodic pulses. The calibration with random pulses was accomplished by measuring the counting rate of a beta-gamma source using a G-M tube and the Counting Rate Meter and checking the "Counts per Minute" meter reading against a scaler operating from the "Scaler" pin jack on the Counting Rate Meter front panel. The calibration with periodic

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MDDC - 766 Counting Rate Meter Based on A Design by M. I. T , by R. L. Sternberg, 13 p., n.d., decl. 12/31/46. (Cont'd from page 487).

pulses was done using the pulse generator. Although the calibrat'on has shown a tendency to drift from day to day th·s ond·tion may improve when the meter is put into continuous operation.

A drawing of the instrument designed at M. I. T. is inclosed.

MDDC - 767 Nuclear Energy for Power Production, by W. F. Davidson, 22 p., n.d., decl. 3/18/47.

While the fundamental principles on which the design of nuclear power plants are understood in broad outline and have been demonstrated an extensive and costly program of analysis and experimental investigation must be carried out before the first practically useful power plant can be constructed. However, there seem to be good reasons to expect that within a decade it will be possible, technically to have nuclear power plants of several thousand kilowatts capacity.

At this time estimates of construction and operating costs can be little more than intelligent guesses. An analysis of such an estimate prepared for the United Nations Atomic Energy Commission indicates that nuclear power plants may be able to deliver power at costs comparable with those from coal-burning power plants. Such p ants may first find use in regions without water power where coal and oil can be obtained only after expensive shipment.

The estimates show construction costs several times greater than for coal plants, and higher labor costs. It is also indicated that fixed-charge rates on the cost of the plant will probably be considerably higher than those for fuel burning power plants, at least during the early years of development and until experience has provided a basis on which to refine design so as to eliminate, where practical, the features resulting in the higher costs.

No consideration has been given in the study to the effects of national or international laws or agreements for the control of atomic energy in fissionable materials. The effects are certain to be far-reaching, and they may have a profound influence on the future technological development in the field, if for no other reason than their influence on the rate at which the early engineering development programs can be prosecuted.

MDDC - 768 Ultra Short Duration Fl h Radiographs by J. C. Clark. 5 p. n.d decl. 3/24/47.

The Westinghouse flash radiographic equipment used is described in principle in a report by C. M. Slack and L. F. Ehrke. (J.A.P. 12 165, 1941).

It had earlier been determined by measurements of the radiographs of such objects as rifle bullets in flight that the duration of the X-ray discharge produced by Slack's equipment was of the order of one microsecond, but little information could be obtained from these radiographs about the nature of the X-ray burst. Extremely fast-response type ionization chambers and associated electronic circuits which cou d be used for analyzing the characteristics of the X-ray burst of the kind produced by this equipment are in themselves a major research project, and a much simpler and more direct method has been adopted. This consists in radiographing a very thin foil indicator strip cemented along the top of a small piece of explosive of high detonation velocity as the detonation proceeds along the piece of explosive. The radiograph thus obtained furnishes direct evidence of all of the characteristics of the X-ray burst except the effective wave length of the X-rays, and such a determination can be made with the step wedge filter technique.

Flash radiographs were obtained wherein the single X-ray burst had a duration of no longer than 10^{-7} seconds.

MDDC - 769 Techniques in the Use of Carbon 14, by W. G Dauben, J C. Reid, and P. E. Yankwich, 15 p. . January 29, 1947 (BC-40) (See also Analytical Chemistry Vol. 19, p. 828-835, November 1947.)

A method is described for the incorporation of isotopic carbon dioxide into organic compounds by the Grignard reaction. The yields obtained vary from 80 to 95%, based on carbon dioxide. A detailed description is given for the conversion of organic substance into a form suitable for radioactivity determination and the construction and use of equipment employed to determine relative radioactivity of such samples.

MDDC - 770 Transient Response of Damped Linear Net-works With Particular Regard to Widespread Amplifiers, by W. C. Elmore, 24 p., February 27, 1947.

When the transient response of a linear network to an applied unit step function consists of monotonic rise to a final constant value, it is found possible to define delay time and rise time in such a way that these quantities can be computed very simply from the Laplace system function of the network. The usefulness of the new definitions is illustrated by applications to multi-stage wideband amplifiers for which a number of general theorems are proved. In addition an investigation of a certain class of two-terminal interstage networks is made in an endeavor to find the network giving the highest possible gain—rise time quotient consistent with a monotonic transient response to a step function.

MDDC - 771 A Thermal Neutron Velocity Selector and its Application to the Measurement of the Cross Section of Boron, by E. Fermi, J. Marshall, and L. Marshall, 10 p., n.d., decl. 4/4/47. (See also Physical Review, Vol. 72, p. 193-196, Aug. 1, 1947.)

A mechanical velocity selector for neutrons < 0.3 eV is described, consisting essentially of a sandwich pile of alternate Cd and Al foils, rotated as a shutter in the neutron beam about an axis parallel to the plane of the foils. Using it, the cross-section of B for neutrons of 2,200 m/sec velocity was found to be 703 barns. A diagram of the selector is included.

MDDC - 772 The Equation of State of Air, by K. Fuchs and R. E. Peierls. 99 p., n.d., decl. 4/2/47.

3.1 Equation of State of Air Between 2.10^4 and 2.10^6 Degrees

Calculations are briefly described on the equation of state of air in the region in which all molecules have been completely dissociated into atoms, and in which the atoms are being stripped of their electtons, until, in the neighborhood of 2 million degrees, there are only nuclei and free electrons left.

Results are collected in a series of tables which present the data in a form convenient for use.

MDDC - 773 The Model 200 Pulse Counter by W. A. Higinbotham, J. Gallagher, and M. Sands, 30 p. October 10, 1946. (See also Review of Scientific Instruments, Vol 18, p. 706-715. October 1947.)

A complete general purpose electronic pulse counter is described which consists of an amplitude discriminator, scale-of-64, and register driver, and its suitable for use with pulse amplifiers in making nuclear measurements. Photographs and circuit diagrams are included.

MDDC - 774 L-Converted Isomeric Transition, by M. Goldhaber, C. O. Muehlhause, and S. J. Turkel, 3 p., January 1947. (See also Physical Review Vol. 71 p. 372, March 15, 1947).

It is shown that the 1.5 minute activity of Ir formed by capture of slow neutrons in Ir does not decay by β-emission as previously believed, but by an isomeric transition which is largely converted in the L-shell. L-radiation of Ir has been detected and the energy of the transition has been determined by absorption of the internal conversion electrons to be $\sim$58 Kev. A γ-ray component of similar energy has been found. This energy is smaller than the energy needed for conversion in the K-shell of Ir (77 Kev).

MDDC - 775 This document is temporarily unavailable.

MDDC - 776 Method for the Preparation of Butt-Welded Thermocouples Using 3-Mil Diameter Wire, by E. F Hammel, 8 p., January 24, 1947.

Apparatus and procedures are described for the production of butt-welded thermocouples using 3-mil-diameter wires. Photomicrographs of the resulting junctions are included.

MDDC - 777 Purification of Uranium Oxide, by J. I. Hoffman, 10 p., n.d., decl. 3/18/47.

A procedure is given for the purification of uranium oxide by converting the oxide to the nitrate and partitioning the nitrate between a large amount of ether and a relatively small amount of water. In modified form, the procedure was found to be applicable to pitchblende and carnotite ore concentrates.

MDDC - 778 A 160/1500 Volt Regulated Power Supply, by P. W. Howells, 28 p., August 1946.

Present trends in the developments of electronic devices have created a need for a regulated power supply unit having different characteristics from those of power supply units in common use today. Such devices as klystron oscillators, phototubes and electron multipliers, cathode ray tube circuits, multi-stage direct-coupled amplifiers, and mass spectrometers may require a source of stabilized d-c power at a voltage higher than that obtainable from most of the present commercially available power supplies. In many of these applications, special requirements of low hum, stability, low output impedance, or continuous adjustment of output voltage over a wide range make most power supplies unsuitable.

To meet the requirements of this field, the General Electric Company has developed the 160/1500 Volt Regulated Power Supply, Cat. No. 5107862G1, Type PS-5. This regulated power supply was intended to provide a convenient source of d-c power at moderately high voltage, continuously adjustable over a wide range by means of a single control. As a laboratory instrument, such a supply has a low output ripple voltage, good stability of output voltage with respect to line voltage or load current changes, and a low output impedance to minimize the possibility of undesired coupling between common load circuits through the power supply. The size and weight of the unit allows it to be readily portable. The performance specifications of the finished unit are shown.

Detailed discussion of operation, as well as photographs and circuit diagrams are included.

MDDC - 779 Fifty-five-hour Element 61 Formed in Fission, by M. G. Inghram, D. C. Hess, Jr., R. J. Hayden, and G. W. Parker, 3 p. January 29, 1947. (See also Physical Review, Vol. 71, p. 743, 1947.)

Element 61 was chemically separated from fission products. It was mixed with normal Nd and dispersed in a mass spectrograph. The photographic plate was placed successively against various parts of another plate for times calculated to give equal intensity at mass 149 if the half-life were 49 hrs. The results indicate that 61^{149} had a half-life of 55 hrs., and that 61^{147} has a half-life of about 3.7 years. The Sm+Eu fraction of the original fission sample was also analyzed by this method. Sm^{153} has a half-life of 47 hrs.; Sm^{151}, about 20 years. Eu^{156} has a half-life of about 15.4 days; Eu^{155}, 2-3 years.

MDDC - 780 Table of Legendre Polynomials P_n (cos) for N=O (1) 20, and =O^O (1) 180^O To Six Decimals, by W. Lane and D. Sweeney, 10 p., February 12, 1947 (LADC-361)

A table of legendre Polynomials was computed for use because no tables of the functions of the desired range were available from other sources. I. B. M. punched card equipment was used throughout in the calculation of the table, which is based on the recursion formula:

$$P_n(\cos\ ) = \frac{1}{n} \quad P_{n-1}(\cos\ ) \cdot \cos\ \cdot (2_{n-1})^{-} P_{n-2}(\cos\ ) \cdot (n^{-1}$$

using the two values P_0 (cos) = 1.0 and P_1 (cos)= cos for the starting values. The argument, ranges from O^O through 180^O at intervals of 1^O; the range of n is from O through 20 at intervals of unity. Six decimal places were carried throughout the computations, but due to the cumulative effect of constant mechanical rounding, the sixth place error of $\pm \frac{1}{2}$ for n=1 increases gradually until it becomes greater than 1 beyond n=15. The table is accurate to six decimal places for values of n 15, and five decimal places for values of n 15.

MDDC - 781 Velocity Analyzer, by W. C. Meecham, 6 p., n.d. decl. 4/2/47.

Description of a velociyt analyzer (with diagrams) is given.

It is a device for measuring the velocities of charged particles which comprises pairs of spaced electrodes, a collector for charged particles, and means for propelling charged particles in a direction so as to pass between the pairs of electrodes. The pairs of electrodes and the collector are so arranged to permit passage of the charged particles between them to the collector plate. Means are provided for applying an alternating substantially square wave potential of known frequency to the pairs of electrodes so that adjacent pairs are opposite in phase and so that one half-cycle of the wave appears as zero potential between the pairs of electrodes.

MDDC - 782 Van De Graaff Ion Source With Axial Magnetic Field, by F. Oppenheimer and A. Hudgins, 3 p., n.d., decl. 3/17/47. (BP-61)

Preliminaty results are reported of tests on a Van de Graaff ion source with an axial magnetic field.

The use of an axial magentic field to improve the performance of Van de Graaff ion sources has been suggested by many people. The magnetic field should be beneficial in two respects. The rate of flow of ions from the central electron column should be greatly reduced, thus enabling the maintenance of much higher ion densities at a lower ion production rate. The use of an axial magnetic field should thus allow operation at gas pressures many times lower than in the conventiaonal types of arc.

Secondly, the fact that the primary electrons from a filament can be collimated by the field allows one to have a much higher electron current density in the immediate neighborhood of the exit hole of the ion source.

An ion source with an axial magnetic field has been tested and it is found that it will operate quite steadily under the following approximate conditions:

	Exit hole size 3/64	3/32
Focused, magnetically resolved proton current	300 μa	700 μa
Focused, magnetically resolved molecular current	80	100
Focused, magnetically resolved triatomic current	70	90
Arc current	5 amps	8 amps
Arc voltage	80-100 v	80-100 v
Pressure H_2	6-8 μ of H	
Maximum magnetic field	900 gauss	
Probe voltage	3 kv	

Figure shows a schematic diagram of the test source.

MDDC - 783 Health-Physics, Instrumentation, and Radiation Protection, by H. M. Parker, 101 p., n.d., decl. 3/25/47.

Shortly after the discovery of X-rays and radium the damaging properties of penetrating radiation were observed. The earliest injuries affected the surface of the body, notably the fingers and hands, and steps were taken to adjust the exposure of the individual in such a manner that these injuries would not arise in future cases. It was some time before more insidious forms of damage, frequently not accompanied by easily recognized early signs of injury, were observed. This period was one in which many people exposed to radiation were subsequently afflicted with anemia. Throughout the history of the use of penetrating radiation, steps have been taken to organize the work program in such a manner that observed injuries would not be reproduced in the future.

This paper summarizes the history and functions of radiation health protection under the following topics:

Scope of health physics; past experience in protection; exposure standards; organization and functions of a typical health-physics group; instruments; some elementary formulae and calculation methods.

A bibliography of 104 references is included.

MDDC - 784 Synthesis of Ethyl Trifluoracetate, by J. C. Reid, 2 p. February 7, 1947 (BC-41)

The straightforward synthesis of ethyl trifluoracetate by esterification of trifluoracetic acid involves the somewhat tedious process of isolating the acid from the reaction mixture in which it is formed. This paper described the direct esterification of the acid without isolating it from the reaction mixture.

Potassium trifluoracetate is formed by oxidation of 1,1,2-trichloro-3,3,3-trifluoropropene with alkaline permanganate. After reducing excess permanganate with sulfur dioxide and filtering off the manganess dioxide, the solution is acidified and a large excess of ethanol is added. The ester can then be distilled out by using an efficient column despite the very large amount of water present. This is possible because the esterification is rapid and because the ester forms a low boiling azeotrope which can be cleanly separated from ethanol. The azeotrope is a ternary mixture of ester, alcohol and water containing 88 wt. % ester and boiling at 54°.

The ester is recovered from the azeotrope by distillation from sulfuric acid. The yield of purified ester, based on trichlorotrifluoropropene, is 73%.

MDDC - 785 Studies in the Preparation of Organic Radio-Halides by J. W. Richter and G. E. Boyd. 34 p. January 6, 1947 (MonC-59)

A convenient method of preparing normal alkyl bromides, as well as isopropyl and sec-butyl bromides, is the action of ammonium bromide and sulfuric acid on the corresponding alcohol. Alcohols of more than five carbon atoms are insoluble in the sulfuric acid-salt solutions, so that the reaction for these alcohols is too slow to be practical. n-Propyl bromide was prepared in a 75% yield from n-propyl alcohol. The technique of carrying out a reaction on small quantities (two grams of material) and then adding the desired compound as carrier is very helpful in the preparation of radioactive organic halides. In this manner, the time for a reaction to reach completion is reduced, and the product is easier to purify because of the small quantities of side products.

A small, efficient fractionating column was developed for the fractional distillation of 10 to 20 ml of solution. Also, an extraction apparatus which enables the operator to separate and wash solutions without inhaling the volatile organic halides is described.

Summary of Results on the Preparation of Organic Radio-Bromides.

Compound	Method of Preparation	Yield of activity in Radiohalide	Specific Activity c/m/g Br at 9.4% Geometry
Ethyl bromide	$Al_2Br_6^*$ + ethyl bromide	93%	10,660
Bromobenzene	$Al_2Br_6^*$ + bromobenzene	68	8,600
n-propyl bromide	$NH_4Br_6^*$ + H_2SO_4 + C_3H_7OH	75	3,900
Isopropyl bromide	$AgBr_6^*$ + isopropyl iodide	65	9,000
tert-butyl bromide	HBr* + tert-butyl alcohol	65	7,950

MDDC - 786 On the Magnetic Moment of the Deuteron, by R. G. Sachs, 17 p., n.d., decl. 3/24/47. (See also Physical Review, Vol.72 p. 91-98 July 15, 1947)

An attempt is made to calculate the relativistic correction to the magnetic moment of the deuteron in order to determine the D state probability from the accurately determined proton, deuteron, and neutron moments. It is found that the resulting corrections depend strongly on the transformation properties of the nuclear fields. If a scalar field is assumed the D state probability is estimated to be 6.0% while for a vector field the corresponding estimate is 2.4%. The effect of a noncentral tensor interaction is included in these estimates. It is concluded that the magnetic moment cannot be used for precision determination of the amplitude of the D function. The results also indicate that little can be said at this time concerning the question of the additivity of the intrinsic proton and neutron moments.

MDDC - 787 Nuclear Properties of U^{233}: A New Fissionable Isotope of Uranium, by G. T. Seaborg, J. W. Gofman, and R. W. Stoughton, 1 p., April 15, 1942. (ANL-HDY-95) (See also Physical Review 71, p. 378, 1947.)

The whole text of this document is reproduced herewith.

The bombardment of thorium with slow neutrons produces Th^{233} (by the reaction $Th^{232}(n,\gamma)Th^{233}$), which emits beta-particles and has a half-life of 23.5 minutes. The daughter of Th^{233} is the 27.4-day beta-emitting Pa^{233} which in turn decays to U^{233}. Authors have measured the radioactive and the fission properties of U^{233}. The measurements on a sample of U^{233} weighing 3.8 micrograms show that this isotope undergoes fission with neutrons. The same result was obtained in a check experiment with another sample of U^{233} weighing 0.8 microgram.

MDDC - 788 A Mass Spectroscope for Analysis in the Low Range, by W. Siri, 17 p., February 20, 1947 (BP-58) (See also Review of Scientific Instruments 18, p. 540-545, August 1947.)

A simplified and portable design of the 180° deflection type mass spectroscope was developed for quantitative analysis in the mass range from 4 to 65. The principal features include an oscillating accelerating voltage, permanent magnetic field, the use of A. C. amplifiers and an oscilloscope. Successful application has been made to fixed gas, liquid and solid samples and continuously flowing gases with changing component concentration. Accuracy from isotope ratio determinations is of the order of 2-5%.

MDDC - 789 Mass Spectrograph for Rapid Analysis in Low Mass Range, by W. Siri, 2p., January 18, 1947.

A brief resume is given for oral presentation. See MDDC-783 for more complete presentation.

MDDC - 790 Some Exchange Experiments Involving Ferrocyanide and Ferricyanide Ions, by R. C. Thompson, 7 p., January 29, 1947. (BC-39)

Exchange reactions involving the following pairs of ions have been investigated using radioactive iron: ferrocyanide and ferricyanide, ferric and ferricyanide, ferric and ferrocyanide, ferrous and ferrocyanide, and ferrous and ferricyanide. The exchange of activity between ferrocyanide and ferricyanide ions can be accomplished by an oxidation-reduction reaction involving only the transfer of an electron. The other reactions investigated require the exchange of an atom between molecules.

An immeasurably rapid exchange of electrons between ferrocyanide and ferricyanide ions in neutral solution, 1 N HCl and 0.05 N NaOH has been observed.

No exchange of iron atoms was observed between any of the following pairs of ions: ferric and ferricyanide, ferric and ferrocyanide, ferrous and ferrocyanide, and ferrous and ferricyanide.

MDDC - 791 A Portable Pulse Generator, by W. A. Titterton, 14 p., January 29, 1947 (LADC-348) (See also Review of Scientific Instruments Vol. 18, p. 639-643 September 1947.)

In the routine testing of electronic equipment, particularly in a nuclear laboratory, there is frequently a requirement for a simple, lightweight pulse generator. The instrument described is built to fill such a role. It provides rectangular pulses of duration 1, 10 and 100 μsecs (or other chosen values) of amplitude smoothly variable from 0 to 75 v. Either positive or negative pulses are available from low-impedance sources, and an internal repetition rate, covering the range 1 to 10,000 cycles per sec, is included. In addition, the circuit may be driven from an external signal generator, or a source of random pulses, where this is desired. The instrument has proved of utility in circuit research when used as a source of pulses in conjunction with a synchroscope.

MDDC - 792 Atomic Power Engineering, by F. C. Von der Lage, 49 p., n.d. decl. 3/31/47.

A monograph is presented on the past, present, and probable future development of atomic power engineering for reading by young persons considering a career in this field.

Topics include: atomic energy and its source; definition of atomic power engineering and atomic power engineers; history of atomic power and the power pile; the future of atomic power engineering; types of personnel needed in atomic power development; present location of atomic power development employment; future requirements for atomic power engineering personnel; duties of the atomic power engineers; personal aptitudes required; how to choose a profession. pre-college educational requirements; under-graduate college training for atomic power engineers, college graduate school training; beginning employment and line of promotion; professional income; advantages of the career; disadvantages of the career; a day in the life of an atomic engineer.

MDDC - 793 Chemical Forms Assumed by C^{14} Produced by Neutron Irradiation of Beryllium Nitride, by P. E. Yankwich, 4., February 3, 1947 (BC - 36). (See also Journal of Chemical Physics, Vol. 15, p. 374-375, June, 1947)

As an extension of earlier work, chemical fractionations have been made of the C^{14} activity induced in powered beryllium nitride by neutron bombardment. The nuclear reaction $N^{14}(n,p)C^{14}$ gives the product atom an energy of at least 40,000 ev. Though the velocity associated with such a recoil carbon fourteen atom is approximately that of an electron of 1.6 ev energy, definite chemical effects can be expected.

Solution of the irradiated powder gave activities corresponding to methane, carbon monoxide, carbon dioxide, hydrogen cyanide, methanol, and formic acid. Formaldehyde was not found. The distribution of activit'es is not affected by the acidity of the solvent.

MDDC - 794 Mercury Slug Flowmeter, by K. L. Yudowitch, 3 p., n.d., decl. 3/24/47.

Incidental to other researches at the Manhattan Project, the author developed with J. F Bac n and other associates a meter to measure small gas flows at various pressures. The requirements of an operating pressure drop of less than 3 mm. of mercury and independence from physical properties of the gas made capillary flowmeters, rotameters and circuit-terminating flowmeters undesirable.

Various designs of absolute displacement meters were investigated. The design which was adopted was suggested by a meter described by Appleby and Avery*. In operation, the mercury slug traverses a spiral path. The spiral was made by winding six mm. pyrex tubing in a plane and allowing it to set on a slightly convex carbon block. This fixes the spiral outlet one to two mm. above the inlet.

The advantages of this meter are: (1) It operates on a low pressure drop. (2) It operates over a broad pressure range (2 to 76 cm). (3) Its operation is independent of the physical properties of the gas being measured. (4) It gives an integrated or average flow-rate, rather than an instantaneous rate.

A drawing is attached.

* Ind. and Eng. Chem. (Anal. Ed.) 15, 349 (1943)

MDDC - 795 Production and Analysis of Radioactive Aerosols, by E. Abrams, 115 p. July 2, 1946.

The biological p ogram calling for exposure of animals to air-borne radioactive materials made it necessary to develop procedures for producing aerosols, exposing animals to the aerosols, and measuring particle size and concentration. Since carrier-free materials were used, techniques were devised for the remote control handling of material with negligible weights, but with high radioactivity so as to obtain maximum deposition in the lungs of the experimental animals.

Of a number of methods of producing aerosols that were investigated, three were extensively used. Atomization of aqueous solutions in a right angle jet atomizer was useful for tracer. But because of the great dilution with air it was not possible to obtain high efficiency. Burning a salt in a D. C. carbon arc was adequate for obtaining high intensity fission product smokes, but failed with Pu where it was necessary to use larger masses of material. High concentration Pu smokes were obtained by wrapping Pu metal in thin aluminum foil and discharging a high energy condenser (1000 joules) through the foil.

To maximize lung deposition and to avoid skin contamination and ingestion anesthetized rats which breathed from a small chamber through glass cannulae were used. This chamber consisted of a 2.8 liter brass cylinder from which 32 rats breathed while lying on a surrounding bakelite superstructure. In the case of the exploding foil it was necessary to use a 4.1 liter cylinder with a partition which protected the rats from the violence of the explosion.

A number of methods were investigated for collecting smoke samples for analysis. The most satisfactory was the thermal precipitator which makes use of the dust-free zone around hot bodies to precipitate all the particles in a sample of air on to a Parlodion-coated microscope cover slip. Concentrations were estimated by doing direct γ and β counts on these cover slips. Later the Parlodion film was stripped off the glass and mounted for particle size observation in the electron microscope. Mean particle size with the methods used in the experiments averaged 0 1 to 0 2 μ

MDDC - 796 Abstract of Material for Possible Presentation to Radiotracer Converence at the University of Chicago, March 3 and 4 , 1947, by D. S. Anthony, 3 p., February 17, 1947.

A condensation of the abstract is given here.

I. Materials

A. $BaC^{14}O_3$ from $Ca(NO_3)_2$. A brief discussion of the probable quality of this product from the standpoint of radiopurity and specific activity is given.

B. $BaC^{14}O_3$ from Be_3N_2. The average over-all specific activity obtained if all of the C^{14} from irradiated Be_3N_2 is converted to $BaCO_3$ is discussed briefly.

C. Other C^{14} containing compounds from Be_3N_2. Work is in progress to determine the distribution of C^{14} between the various fractions and probable groups of fractions as follows: Alkali volatile fraction (65% of total-including CO and saturated and unsaturated hydrocarbons), Acid volatile fractions (about 5% of total - including CO_2 and HCN), and non-volatile oxidizable (30% of total).

II. Techniques

A. For filtering and counting $BaC^{14}O_3$

A slurry of $BaCO_3$ in $Ba(OH)_2$ is run through a porcelain filter disk held between two rubber gaskets. (The disk is made by cutting off all but a few millimeters of the top of a Selas filtering crucible.) After rinsing with water and acetone, the apparatus is disassembled and the filter disk with its cake of carbonate is dried and weighed.

The disk is then mounted in a metal holder which fixes its position in a standard counter housing. Counting is done with a mica-window tube (2.2 to 2.7 mgm/cm^2 window thickness). This counting is thick-sample counting since sufficient carrier is added to give a $BaCO_3$ precipitate of approximately 25 mgm/cm^2. Samples are then corrected for self-absorption to a standard weight of 25 mgm/cm^2. This correction is usually small in magnitude and of course yields relative rather than absolute counts.

B. For continuous monitoring of a gas stream containing C^{14} compounds.

An ionization chamber was inserted as one unit in the gas train used for studying the volatile C^{14} compounds which could be swept out of Be_3N_2 and $Ca(NO_3)_2$ solutions. The dried gas stream was led directly through the ionization chamber, and the current flow from the chamber was amplified in a Beckman microammeter. The Beckman in turn drove a Micromax recorder. The sensitivity of this apparatus was such that about 0.1μc of C^{14} in the chamber gave full scale (10 inches) deflection on the most sensitive scale.

MDDC - 797 A Simple Demonstration of Resonance Scattering, by A. Langsdorf, Jr. and W. Arnold, 1 p., n.d., decl. 3/24/47.

These experiments demonstrate the coincidence of resonance scattering with the principal absorption resonance of In, Ag, and Au. A collimated neutron beam from the Argonne heavy water pile was filtered by cadmium to remove thermal neutrons. Neutrons scattered at right angles by a foil placed at 45 degrees in the beam were detected by activation of a foil or by a BF_3 filled ion chamber and linear amplifier. A graphite scatterer was used as standard non-resonant scatterer. Assuming its cross section is 4.6 barns (cm^2/atom x 10^{24}), a simple comparison of activations gives apparent effective cross sections of the scatterers: (Ag scatterer - Ag detector) 140 barns, (In scatterer - In detector) 120 barns, (Ag scatterer - In detector) 14 barns, (In scatterer - Ag detector) 60 barns, with rather large probable errors. The activations are those of 22 second Ag and 13 second In. The BF_3 chamber detector, using similar scatterers and resonant absorbers of Ag, Au, and In between scatterer and detector show resonant scattering in all three materials. Neither detectors nor scatterers are thin, so peak resonance scattering cross sections should be more than double the experimental values. For further data see MDDC - 953.

MDDC - 798 The Average Gamma Energy Emitted per Beta Particle for Several Radioactive Isotopes, by E. C. Barker, 1 p., February 21, 1947.

The whole document is reproduced herewith.

The total γ-ray energy appearing with a nuclear disintegration can be measured by integration of all energy received from the γ-ray or rays by an infinite homogeneous medium. Using an effectively infinite medium of aluminum, and small ionization chambers to measure the number of ion pairs produced per second at various radii from the source, the average γ energy emitted by the source per β-particle is

$$Q/\beta = 4\pi W\rho \int_0^\infty n_r r^2 dr$$

where W is the average energy lost by the secondary electrons per ion pair formed in air.
ρ is the ratio of the rate of loss of energy by the secondary electrons in the medium and in air
n_r is the ionization per unit volume produced in a small air-filled cavity at a distance r from the source.

The measurements required are of (1) ionization current, (2) volume of the ionization chamber, (3) source strength in terms of β-particles per second, (4) chamber position.

The average γ energy per β-particle is 4.17 Mev for Na^{24}, 0.336 Mev for Au^{198} and 2.6 Mev for Ga^{72}.

MDDC - 799 This is an abstract of MDDC-839

MDDC - 800 The Beta-Gamma Hand and Foot Counters, by W. H. Bradley, 3 p., May 1946.

This is basically a counting rate meter, with an alarm circuit, operating from four GM tubes as the detecting elements.

The Hand Counter comprises four logarithmic counting rate meters working from four GM tubes mounted individually, with associated electronic circuits, in suitable shields with a metal mesh type of window. Both sides of both hands are sampled simultaneously.

In the Foot Counter, two GM tubes are paralleled and mounted in a suitable mesh window shield with the electronic circuit; the foot counter uses only two counting rate meters, and both feet are sampled simultaneously.

Each circuit is built in two parts; two tubes are in the shield and the balance of the circuit is in the electronic unit which is a standard 17" x 13" chassis.

Circuit diagrams are included.

MDDC - 801 Test Results On Bias Setting For the Chicago Scaler Offner Models, by W. Bradley, B. Epstein, and E. Wakefield, 8 p., August 12, 1944. (CP-2086)

The counting accuracy of the Chicago Scalers, Models 961A and 961B, is a function of the bias setting of the limiter (V2). This report gives quantitative data supporting this thesis. A method of making bias settings is suggested.

Three types of tests were run: (1) Five scalers with the same sensitivity setting were operating simultaneously from a Model 5 pulse generator triggered by a 60 cycle sine wave. This was repeated using pulses from a Geiger-Muller tube fed through a cathode-follower. Both the circuit diagram of the pulse generator and the cathode-follower have been circulated before. The pulse from this generator has a linear rise in about 2×10^{-7} second, decays linearly from 2×10^{-6} second to about 9/10 the original height, then falls linearly in 2×10^{-7} second. (2) The sensitivity of each scaler was then changed, the test repeated, the average counts recorded and the percent deviation from the average plotted, (3) Three separate scalers were individually connected to a G-M tube. Count versus bias setting was recorded. In tests 1 and 2, the line voltage was set with a variac but not regulated; in test 3, the line voltage was regulated with a Sola transformer.

MDDC - 802 A Threefold Coincidence System Based Upon a 10^{-6} Second Resolution Time, by W. H. Bradley and B. Epstein, 15 p., October 23, 1944. (CP-2725).

This is a report upon the design, construction, and method of testing of a one microsecond coincidence time system. This system was designed to meet the need of scientists who required a better resolution time than had theretofore been used. The entire effort falls naturally into three parts: the gross design and testing method, the detail layout and construction and the modification and testing. Many of the ideas used in this circuit were first incorporated into a system built about ten months ago. The results were highly satisfactory, and the first reports by users are favorable.

Coincidence circuits have been used heretofore largely for cosmic ray measurements, where no serious background of interfering events could affect the results, and where the counting rate is low. But recently it has been found desirable to measure beta particles in a high background of gamma rays. This has necessitated using a coincidence circuit with a resolution time of about 10^{-6} second. Older circuits were revised, but great difficulty was encountered in making them fast.

A fresh attack was made along the following lines.

First, the system must have less than one microsecond resolution time throughout. Second, the pulse that triggers the coincidence circuit must be definitive both with respect to width and height. Third, the system must have a good input voltage sensitivity so that it may trigger on the low amplitude pulses occurring during the insensitive time of a G-M tube. And fourth, each channel must be provided with separate switching monitoring components.

Circuit diagrams, and photographs of equipment are included.

MDDC - 803 The Electronic Pressure Transmitter and Self Balancing Relay, by S. Cromer, 17 p., June 20, 1944.

A rugged balanced type precision pressure transmitter has been developed. Several units have been built and placed in operation; they are giving dependable and accurate results.

The transmitter is now being used in conjunction with a simple electronic relay for many problems where continuous automatic pressure recording or control is required.

The principal features incorporated in this transmitter are:

(a) The maximum error in transmitted pressure is less than one-half millimeter of mercury over a pressure range from zero to two atmospheres absolute.
(b) The measuring chamber is of all welded nickel construction to eliminate corrosion and minimize gas consumption.
(c) The volume of the measuring chamber is less than 3 ml, thus in many applications its dead volume is negligible.
(d) The unit is rugged enough to withstand all ordinary laboratory usage. Temperatures as high as 120°C do not affect its accuracy, nor do excessive differential pressures as high as two atmospheres.
(e) Because of its simple design it is being produced at a very reasonable cost.

Photographs and drawings are attached.

MDDC - 804 Diffraction of Neutrons By Hydrogen and Deuterium Containing Crystals, by W. L. Davidson, G. A. Morton, C. G. Shull, and W. O. Wollan, 2 p., n.d., decl. 3/7/47. (See also MDDC-842)

This paper is an abstract and is presented here in its entirety.

A study of the diffraction of neutrons by materials containing hydrogen and deuterium is made. One reason for making such a study is the possibility of locating hydrogen positions in crystals by means of neutron diffraction, whereas with X-rays this cannot in general be accomplished. As an alternative to hydrogen, deuterium may be used in one or more positions in a unit cell to obtain further information about the structure. The measurements were made by the same powder crystal technique as described in a previous paper. The first material studied was NaH which has a cubic structure with $a_0 = 4.88$. Diffraction peaks were observed for the (111), (311) and (331) planes but the intensities from planes of even indices were too small to be measurable. The presence of the peaks with odd indices and the absence of peaks with even indices shows that hydrogen and Na scatter with opposite phase and the coherent scattering amplitudes for Na and H are about equal. In addition the absence of the (400) peak shows that NaH has the NaCl rather than the ZnS structure. Although the diffraction peaks from NaH are easily measurable, they represent only a small fraction of the total scattering, the diffuse scattering being about twice as intense as the peak of the (111) reflection. These results are in agreement with theoretical predictions based on a consideration of the singlet and triplet binding energies of the deuteron. Similar diffraction measurements are being made with NaD and the results of these measurements will be compared with those for NaH.

MDDC - 805 Manufacturing Specifications for the Portable G-M Tube Survey Meter, by J. Dorsey, 9 p., May 30, 1944. (CP-2118)

The report gives an explanation of the electrical operation of the Portable G-M Tube Survey Meter. Also included is a schematic diagram photograph, diagram showing location and position of labels and parts list.

The circuit consists of two tubes: both are diode, triode, pentode types. The 3A8-GT is used as a multivibrator to supply the negative high voltage for the Geiger counter. The negative high voltage is obtained as follows. Assuming that the triode section starts conducting before the pentode section (it makes no difference which side starts first), then the plate of the triode becomes less positive. This action makes the grid of the pentode move negative, raising both the screen and plate voltages. The positive change in screen voltage further increases the potential on the grid of the triode The process is repeated until the bias on the grid of the pentode reaches its cutoff value. At this point there are no changes in voltage taking place, therefore, the charge on the grid of the triode starts to leak off through the resistance R_2. As soon as this occurs the triode plate voltage increases and the process is the reverse of that previously described. All of these actions, of course, take place in a fraction of a second. Due to the rapid change in plate current of the pentode, the 1500 henry reactor acts as a high impedance to the current flow. As a result, a charge is placed on the condenser, C_3, alternating in sign. During the positive cycles electrons are drawn to the diode and held there. During the negative cycle the diode acts as a rectifier and no electrons are collected or lost. With every positive pulse on the diode the charge becomes increasingly negative until an equilibrium condition is reached, that is, until the leakage current is equal to the charging current. Inasmuch as the charge that is collected is negative in sign, the high voltage supply will necessarily be negative with respect to ground potential.

The second tube, ID8-GT, is the tube that integrates the pulses from the counter. The integration takes place in the following manner when a negative pulse from the counter tube is placed on the grid of the triode, the plate voltage rises momentarily. This positive pulse is transmitted to the diode plate through the condenser C_5. Electrons are drawn to the diode and a negative charge is thus collected on the diode and in turn on the grid of the pentode. This increase in negative bias on the grid causes the plate voltage to rise and is shown as a positive reading on the microammeter M. The more numerous the pulses, the greater the reading. By using a grid leak resistor of 20 megohms, the effective voltage height of the pulses is increased. If less sensitivity is desired a smaller leak resistor may be used so that the effective pulse height is decreased. Another method of decreasing sensitivity is by changing the normal bias on the grid of the pentode.

MDDC - 806 The Shielding of Nuclear Reactions, by M. L. Goldberger, 15 p., n.d., decl. 3/24/47.

An understanding of the problem of shielding is important not only in the construction of nuclear reactors but also in the carrying out of experiments with radioactive substances as well as with piles. The problem may be divided into roughly three classes: (1) penetration of shields, (2) reflection of radiations around screens and streaming through shield openings, (3) induced activity in samples, equipment, etc. The first two problems are considered. The effects of γ-rays, β-rays, and neutrons in the energy range 3 - 4 Mev and below are discussed. The biological effects of β-rays are produced by direct ionization of tissue, whereas those of γ-rays are primarily Compton electrons, and in the case of neutrons, the effects are due to proton recoils and capture of neutrons by protons and the subsequent 2.17 Mev γ-rays.

A summary of the problems connected with the protection of personnel from the radiation coming from a pile is given. The tolerance doses due to the various radiations are computed and methods are given for estimating the thickness of protective shields in certain practical cases.

MDDC - 807 Resonance Scattering of Neutrons by Mn^{55}, by S. P. Harris, F. G. P. Seidl, and A. S. Langsdorf, Jr., n.d., decl. 3/25/47. (See also Physical Review Vol. 72, p. 168, July 15, 1947)

This report is an abstract only and the whole text is reproduced herewith.

Evidence has been previously obtained that manganese has a strong neutron scattering resonance in the neighborhood of its absorption resonance at about 250 ev. Again the large predominance of scattering over absorption was demonstrated by comparing "poor geometry" and "good geometry" transmission through a manganese foil. Moreover, using 0.024 gm/cm^2 manganese detectors aligned 200 cm behind a 0.0030 gm/cm^2 scatterer consisting of $MnSO_4$ dissolved in D_2O, the transmission of a neutron beam from the heavy water pile was observed. The beam was filtered through enriched boron of thicknesses equivalent to 0.46, 0.78, or 1.10 gm/cm^2 B^{10}. Counting rates proportional to the transmission by pure D_2O were 117.6, 493.5, 263.0 cpm, respectively, for the above B^{10} filters. With the same amount of D_2O plus $MnSO_4$, 1062.1, 475.4, and 258.7 was obtained, the statistical error being 0.7%. The effective transmission cross section was $1900 + 350 \times 10^{-24}$ cm^2 for the incident neutrons passed by 0.46 gm/cm^2 B^{10} and removed by 1.10 gm/cm^2 or passed and removed by 0.46 gm/cm^2 and 0.78 gm/cm^2 or 0.78 gm/cm^2 and 1.10 gm/cm^2. A numerical calculation indicates these data to be consistent with a peak scattering cross section of 5000×10^{-24} cm^2 per atom. When counting rates due to more penetrating neutrons are not subtracted, lower effective cross sections are obtained; this is evidence for higher resonances.

MDDC - 808 **Physical Properties of Uranyl Sulfate Solutions, by L. Helmholz and G. Friedlander, 10 p., December 15, 1943, (LADC-218).**

Measurements are reported of the solubility of uranyl sulfate in water at several temperatures, of the density of uranyl sulfate solutions as a function of concentration, of the variation of density of uranyl sulfate solutions of three different concentrations over a temperature range from 0°C to about 93°C, and of the pH of uranyl sulfate solutions as a function of concentration as well as of temperature. The pH measurements were taken on uranyl sulfate samples prepared in several different ways and some conclusions are drawn as to the purity of these samples.

MDDC - 809 **This is an abstract of MDDC-849**

MDDC - 810 A Linear Amplifier for General Laboratory Use, by W. H. Jordon and P. R. Bell, 1 p., November 21, 1946.

This paper is an abstract and is presented here in its entirety.

Twelve linear amplifiers have been built for general laboratory use. Feedback circuits have been used to stabilize the gain and improve the linearity. The high frequency cut-off of the amplifier can be varied by means of a three position switch that changes the amount of capacitance and resistance in the feedback network. The low frequency cut-off is determined by a simple resistance-capacitance differentiator that is switched to match the high frequency response. The response of the amplifier to a voltage step applied to the input is a single pulse of fairly symmetric shape. The pulse rise time (10% to 90%) is 0.15μsec for the wide-band position, 0.7μsec for the medium-band position, and 4μsec in the narrow-band position. The amplifier will deliver pulses up to 100 volts for direct oscilloscope deflection, or 5 volts for driving a low impedance line.

A pulse height selector is included on the amplifier chassis. It has been designed to measure accurately pulse heights up to 100 volts, independent of pulse duration or duty cycle. It delivers a pulse 3 volts high and 0.5μsec in length for scaler operation.

MDDC - 811 New Developments in Instruments for Counting and Detecting Nuclear Particles, by W. H. Jordon, 9 p., March 7, 1941.

Instruments for detecting and counting nuclear particles have improved considerably in the past five years. There have been no revolutionary discoveries - Geiger counters, ion chambers, linear amplifiers, scalers, and scopes still are used. The tools are still the same but the design and capabilities of them have improved. This is due to several factors. The tubes are better, circuit techniques are better, and knowledge of the detailed operation has considerably increased, enabling the tubes to be used more effectively. Components such as condensers and resistors are more reliable and have longer life so that one can build more complex circuits without having to worry about whether the instruments will function long enough to get the data.

Individual nuclear particles are not detected directly but rather by the ionization they produce. There are ionization chambers, Geiger counters, proportional counters, cloud chambers, secondary electron multipliers, crystal counters, fluorescent screens. In many cases it is necessary to follow these instruments with amplifiers, pulse height selectors, and scalers. These are the primary tools of the nuclear physicist and is the subject of the talk.

Ionization chambers, linear amplifiers, scalers, Geiger counters, crystal counters, and proportional counters are discussed in detail.

MDDC - 812 Ranges in Air of Plutonium Fission Fragments as a Function of Their Mass, by S. Katcoff and J. A. Miskel, 4 p., October 16, 1946. (LADC 316).

It is possible to effect a partial separation of fission products by taking advantage of the variation in the range of fission fragments as a function of their mass. The same phenomenon can be used to determine the mass numbers of previously unassigned fission products. In the experiments reported the ranges in air of seven plutonium fission products have been determined and mass numbers have been assigned to two of these. The straggling in the range has been determined for each of these also.

MDDC - 813 The Rate of Exchange of U (IV) and U (VI) by E. L. King, 1 p., n.d., decl. 3/24/47.

This document is an abstract and the whole text is reproduced herewith.

The rate of exchange of uranium (IV) and uranium (VI) was measured in various perchloric acid and hydrochloric acid solutions at room temperature. It was found to be extremely slow. Since uranium (VI) is oxygenated while uranium (IV) is probably not, the process of exchange involves a breaking and reforming of bonds. Such processes are generally slow.

MDDC - 814 Oxidation-Reduction Potentials of Plutonium Couples as a Function of pH by K. A. Kraus, 30 p. January 23, 1947. (CN-2830)

The existing knowledge of the hydrolytic behavior of Pu(III), Pu(IV), Pu(V) and Pu(VI) were combined with the potential data for the various Pu couples in acidic solution, and the potentials of the couples as a function of pH were evaluated. Due mainly to the uncertainties regarding the hydrolytic behavior of Pu(VI) and the free energy of polymerization of Pu (IV) the potentials at high pH are only approximate, but can serve as a guide in the elucidation of the chemistry of plutonium in weakly acidic, neutral, and alkaline solutions. For example, it can be deduced from these calculated potentials that near pH 3 Pu(III) should be oxidized to Pu(IV) by hydrogen peroxide (rather than Pu(IV) reduced), that near pH 7 Pu(III) can be oxidized by water to Pu(IV), that there exists an optimum region for thermodynamic stability of Pu(V), and that reduction of Pu(VI) by water to Pu(V) is barely possible.

MDDC - 815 Drawings, Los Alamos, 93 p., n.d., decl. 3/25/47 (LADC-110)

Miscellaneous drawings of circuit diagrams and panel and chassis layouts of a great variety of electronic equipment including amplifier circuits, coincidence analyzers, magnetic pulsers, preamplifiers, multiple trigger circuits, interval meters, delay analyzers, oscillators, oscilloscope panels, velocity meters, scalers, etc.

MDDC - 816 Spectrophotometric Determination of Sub-Microgram Amounts of Boron by C. F. Metz, 38 p. June 7, 1945 (LADC-172)

A method for the quantitative estimation of boron in amounts ranging from 0.1 micrograms to 0.5 micrograms is demonstrated for different types of materials. Distillation of methyl borate from a hydrochloric acid or nitrate acid solution is shown to be possible providing acid concentration is not too high. Recoveries from 80 to 1000 per cent can be obtained of the boron added in quantities of 0.1 to 0.5 micrograms. It is also shown that the exclusion of atmospheric carbon dioxide in latter stages of analysis increases the recovery factor.

MDDC - 817 Test Results on Clinton Alpha Amplifier Used with an Offner Columbia Scaler, by H. E. Ostdahl, 15 p., May 8, 1944. (CP - 1616 [A-2291].)

The circuit for the Clinton alpha amplifier which is used with an Offner scaler is attached to the report. It consists of a preamplifier mounted in a cylindrical alpha chamber, followed by a three stage amplifier and a pulse height selector in a separate cabinet. Pulses are fed from the pulse height selector in the amplifier to the input tube of the Offner scaler.

Through the third stage of the amplifier, this circuit is exactly the same as the California circuit used by the chemical section for alpha counting.

A type 961 Offner scaler was used for these tests. None of the latest Offner scalers, type 961A, were available when the tests were made.

Method of testing is given, results are tabulated, computations are made, and eight graphs are given.

It appears that the Clinton amplifiers used with an Offner scaler will give substantially the same performance as that given by the California circuit.

MDDC - 818 Polymerized Trifluorochloroethylene, Plax Corporation, 2 p.,n.d., decl. 3/27/47.

A high polymer of trifluorochloroethylene was produced. This material was a chemically inert high temperature thermoplastic which could be pressed into sheets by flowing out under pressure and otherwise fabricated by conventional methods including continuous extrusion at from 250° to 300°C. The pressed material was a tough high impact strength solid, elastic under stress, which could be readily machined to small tolerances.

The properties of the polymer are such that it can be used as gaskets, valve seats, transparent windows, tubing and other apparatus for chemical use, insulators and supports for electrical equipment, etc. where properties of extreme chemical inertness, freedom from moisture uptake combined with ease of fabrication are desired.

MDDC - 819 Chang and Eng - A Portable Instrument for the Detection of Fast Neutrons in the Presence of Gamma Radiation, by P. W. Reinhardt 22p., March 5, 1947.

The instrument consists of two ionization chambers mounted on a yoke assembly and connected so that the unbalance ionization current can be read on a Lindemann electrometer. One of the chambers is paraffin-coated inside and filled with butane at 30 pounds pressure. The other is filled with argon at about 35 pounds pressure. The pressures in the two chambers are so adjusted that their gamma ray ionization currents balance. Recoil protons ejected from the paraffin and butane by fast neutrons produce a differential ionization current which is read on the electrometer. A fast neutron flux of about 5 neutrons per cm^2 per second can easily be detected.

The electrometer circuit provides for 5 fixed electrometer sensitivities, and an adjustable sensitivity control for maintaining constant sensitivity over a long period of time. The collecting voltage is supplied from a 450-volt battery pack. Exept for the ionization chambers, the entire assembly is housed in an aluminum box 3 5/8" X 4 3/8" X 8 5/8".

Three photographs and twelve sheets of diagrams are included.

MDDC - 820 High Energy Photo-Disintegration of the Deuteron, by M. E. Rose and G. Goertzel. 9 p., n.d., decl. 4/7/47.

As an exploratory investigation of high energy nuclear phenomena, the disintegration of the deuteron by γ-rays in the 50 to 250 Mev range has been considered. The calculations take into account the retardation and the finite range of the nuclear forces, but neglect the forces between nucleons in the final state (because of the large kinetic energies given to the particles), effects of tensor forces in the ground state, and relativistic refinements. These assumptions restrict the validity of the investigation to the energy range indicated. The retardation and higher order multipoles sharply enhance the decrease of cross section with photon energy. The cross section is 3.7×10^{-29} cm^2 at 50 Mev, decreases approximately as $E\gamma^{-4}$ up to about 150 Mev, and considerably more slowly thereafter. In contrast to low energy disintegrations, the angular distributions exhibit a strong peak for forward moving protons, even in the zero-momentum reference frame. Superimposed on this peak are the characteristic interference extrema, for which the consideration of the finite range of nuclear forces is essential. The angular distribution is further modified by the spin transitions, which become relatively more important at high energies.

MDDC - 821 A Report on the Columbia Scaling Circuit by B. Schloss and S. Robinson, 39 p., September 27, 1943. (CT-959)

A detailed study of the circuit was made with the aim of introducing simple changes in order to obtain a circuit that operates more reliably and with considerably less servicing. The results of this study presented in this report fall into four groups—first, a theoretical analysis of the Columbia circuit; second experimental data that support this analysis; third, a discussion of the data, and forth, a description of the redesigned circuit.

MDDC - 822 This is an abstract of MDDC-869.

MDDC - 823 Criticality Studies of the Enriched Uranium-Heavy Water Chain Reacting System, by A. H. Snell, et al., 1 p., February 25, 1947. (See also Physical Review Vol. 72, p. 169, July 15, 1947).

This report is an abstract and is presented here in its entirety.

A general description of a low-power enriched uranium-heavy water chain reactor is given. Some of the procedures of critical experimentation are discussed, and the types of measurements made with the system are described.

MDDC - 824 Response of Hematopoietic System to X-rays, by G. M. Suter, 18 p., n.d., decl. 4/7/47.

The peripheral blood, constantly replenishing itself from its bone marrow and lymphopoietic precursors, is very sensitive to both gamma and neutron radiation.

In the study of peripheral blood, numerous laboratory animals were used. Studies of the effects on the peripheral blood can be divided into two types: that of animals acutely exposed and chronically exposed to whole body radiation. Attempts were made to compare species sensitivity of the various laboratory animals on various bases in order that some conclusions could be made about the effects on humans. On the basis of mortality studies the most sensitive species studied appeared to be the dog, with monkey, rat, and rabbit correspondingly less sensitive. It was found difficult to draw such conclusions from the study of the blood of these animals.

The site of injury with X-radiation and neutron radiation appeared to be directly in the blood-forming organs, the bone marrow, lymph nodes, and spleen. The peripheral blood showed only slight changes when isolated and radiated directly.

Chronic studies were made for purposes of establishing tolerance both to X-ray and neutron radiation.

Experimental results are summarized in ten graphs and two tables.

MDDC - 825 Studies on Acquired Tolerance to Uranium, by A. Tannebaum and H. Silverstone, 18 p., November 29, 1946. (CH-3641)

Generally the injection of uranium salts causes the animal to be more tolerant to subsequent injections. However, experiments with mice, given uranyl nitrate either by injection or feeding did not result in significant acquired tolerance as tested by means of subsequent injections.

There is conclusive evidence, however, that mice previously fed uranyl nitrate do acquire tolerance or resistance to further feeding of the material. This was shown in experiments in which a daily toxic dosage was fed and others in which the daily dosage was gradually increased to lethal levels. In certain instances, at least, the tolerance was of limited degree and duration.

It is concluded that tolerance to uranium can be developed, but that the factors involved are incompletely understood at this time.

MDDC - 826 Fower Supply, by E. W. Titterton, 1 p., October, 1945 (LADC-371)

Circuit diagram.

MDDC - 827 Pulse Unit Model I, by E. W. Titterton, 1 p., September 19, 1945.

This report consists of one circuit diagram of pulse unit Model I.

MDDC - 828 300 Mc Transmitter Pulser (Mock-Up). by E. W. Titterton, 1 p., n.d., decl. 3/31/47. (LADC-376)

One circuit drawing of a 300 Mc transmitter pulser is given.

MDDC - 829 Video Amplifier and Scope, by E. W. Titterton, 1 p., May 1946. (LADC-367).

Circuit diagram is shown for a wide-band amplifier employing two channels, one of which contains a delay line.

MDDC - 830 Emissivity and Temperature Scale for Vacuum Heated Uranium, by H. B. Wahlin, 3 p., n.d., decl. 4 '7 '47.

In this investigation the true and apparent temperatures were determined for uranium which had been heated in a vacuum of 10^{-6} mm or lower for a period of 300 hours or more.

In the procedure flat strips of the metal were used and rolled into hollow cylinders about 3 mm in diameter and 12 cm long. A hole 1/2 mm in diameter was drilled in the side of the cylinders. These were then mounted in a tube connected to a pumping system and evacuated. During the heat treatment continuous pumping was carried on.

At the start the emissivity, calculated from the temperatures of the metal surface and the temperature of the hole (which gives the true temperature), was higher than the final value. Continuous heating at temperatures between 1250°K and 1300 K will clean the surface and lower the emissivity. This cleaning, may be speeded up by turning the heating current off and allowing the cylinder to cool through the recalescence points.

The true and apparent temperatures calculated from the emissivity data are tabulated. The temperature scale used is applicable to clean uranium surface only.

MDDC - 831 Manufacturing Specifications for Higinbotham Scaler, by E. Wakefield, 18 p. November 9, 1944 (CP-2113)

Included in this report is a description of scaling action in a Higinbotham circuit, of operation of the output circuit, and of operation of the regulated high voltage supply. Acceptance and performance specifications are given. Also included are cuts showing the bottom and top view of a scaler of this type. The scaling circuit diagram and major parts list are attached.

To facilitate testing, the circuit of a satisfactory pulse generator is included together with a cathode - follower.

MDDC - 832 A Preliminary Report on the Higinbotham Scaler, by E. Wakefield and S. E. Cooper, 9 p., November 7, 1944. (CP-2110).

The operation of the Higinbotham scaler is described and some tests data are presented together with the circuit diagram. A typical parts list is included. This circuit, particularly the input, is subject to change as experience is gained.

Tests of two scalers indicate that the circuit parameters of a Higinbotham circuit are wide. Further work is envisaged and will be reported on in due course.

It is reported that a Higinbotham has been driven at 800 kc. This was achieved with a special input circuit and a regular pulse. In the early stages precautions were taken about stray capacitances. An oscilloscope was used as a recorder.

MDDC - 833 Specifications for the Types 961-A Scaler, by E. Wakefield, 12 p., October 9, 1944. (CP-2114)

As the result of several meetings between representatives of the Dupont Company and those from the Instrumentation Section of The University of Chicago there has been drawn up these specifications and testing procedure for an acceptable Beta Scaling Circuit.

The type 961A Scale of 64 Scaler is of the modified Columbia design combining one amplifying stage, a limiting stage with adjustable bias set to cut off, six scaling stages feeding into a single tube power amplifier which actuates the recorder. The low voltage and high voltage supply are entirely separate, the latter is adjusted by using a battery as a comparison source.

This scaler, if properly assembled and tuned, will count beta particles acceptably. This conclusion is reached on the basis of tests extending over eight weeks on two Offner Scalers, together with individual counting tests made on 22 more of these circuits.

Photographs, circuit diagram and parts lists are included.

MDDC - 834 The Technical Associates Scaler by E. Wakefield, 7 p., November 8, 1944. (CP-2111)

The Technical Associates Scaler with a scale of 128 is a Columbia type scaler with a potentiometer in the scaling stage plate circuit. Interstage coupling is the conventional variable air capacitance. Its method of operation, its circuit diagram together with its components are given for informational purposes.

MDDC - 835 The Chemical Consequences of Nuclear Changes in Tellurium, by R. R. Williams, 1 p., n.d., decl. 3/24/47 (ANL-NS-188)

This report is an abstract. The entire contents are presented here.

Chemical effects produced by the process of isomeric transition with internal conversion have been examined for the nuclei Te^{127}, Te^{129}, Te^{131}. In particular, the reduction of aqueous TeO_3 following the nuclear process has been observed. A consistent, if superificial, interpretation of the results is offered. The maximum efficiency with which ground and excited states of the isotopes can be chemically separated is proposed as the measure of the conversion coefficient in the isomeric transition.

The chemical change produced in Te ions by slow neutron capture have also been studied and compared with those in isomeric transiton with internal conversion. Oxidation and reduction was again observed with a similar dependence upon solution conditions.

The results suggest that both nuclear processes create similar or identical intermediates which are probably in highly oxidized states. These are stabilized by reacting with the solvent with a distribution among the several stable states determined by the composition of the solvent.

MDDC - 836 Hyperheparinemia - The Cause of the Hemorrhagic Disease Produced by Total Body Exposure to Ionizing Radiation, by J. G. Allen, M. Sanderson, and L. O. Jacobson, 63 p., November 1946.

1. The hemorrhage disease in dogs given a single lethal total body exposure to X ray (450 r) is characterized by a prolonged clotting time.
2. No defeat of the known elements of clotting was demonstrable except for a reduction in the platelet number and the appearance of an anticoagulant not normally present in detectable quantities.
3. The thrombocytopenia per se does not appear to be the important factor responsible for the hemorrhagic disease because the bleeding may occur before the platelets are reduced and transfusions of fresh citrated whole blood did not prevent or stop hemorrhage. Moreover, the factors that specifically inhibit the anticoagulant, restored the clotting time to normal, but did not prevent thrombocytopenia or elevate the platelet count.
4. The anticoagulant reacts like heparin in all respects tested. Its activity was destroyed by specific antiheparin substances such as protamine, toluidine blue and other dyes of the thionin series.
5. Toluidine blue prevented hemorrhage in dogs after X ray exposure and stopped hemorrhage once it appeared.
6. It was possible to isolate from the blood of dogs in the state of hemorrhage an anticoagulant, which on the basis of unit potency per mg. of weight, was as active as the standard sodium acid salt of heparin.
7. The administration of large quantities of vitamin K and vitamin C were ineffective in preventing or stopping hemorrhage..
8. Toluidine blue was ineffective in preventing or curing the hemorrhagic disease produced in normal dogs given dicumarol.
9. Thrombocytopenia, neutropenia, and anemia were produced in normal dogs by the administration of a nitrogen mustard. The whole blood clotting time was not prolonged and hemorrhage did not occur.
10. The hemorrhagic disease associated with over exposure to X-ray was closely correlated with infection. The suggestion was made that the anticoagulant was bound to the immune proteins and was released when the antibodies were exhausted or destroyed. The administration of high titre anti-sera and antitoxins prevented hemorrhage and prolonged the lives of the two dogs in which they were used.

MDDC - 837 Short-Lived Isomeric States of Se^{83} and Ge^{77}, by J. R. Arnold and N. Sugarman, 29 p., March 1947. (See also Journal of Chemical Physics, Vol. 15, p. 703-712, October 1947.)

Extractions of Br from neutron irradiated $SeO_3^=$ solutions revealed the presence of a short-lived state of Se^{83} decaying by β^--emission to 2.4h Br^{83}. The half-life was estimated to lie between 1 and 1½ minutes. The cross-section for formation of the short-lived state was found to be about ten times greater than for the 25m Se^{83}. Direct observation of the radiations from a short-lived Se, effected by measuring the activity of Se irradiated for 20 sec. through Al absorbers, led to a half-life determination of 67 $\pm$ 3 sec. and a β energy of 3.4 Mev. A γ ray was also observed. There is good reason to believe that a genetic relationship exists between this 67s Se and the 2.4h Br^{83} because of the good agreement found between the cross-section of the 67s Se and that of the 2.4h Br^{83} formed from the short-lived Se. Energy considerations lead to the assignment of the 67s Se as an upper state of 25m Se^{83}.

Experiments were performed on the relative fission yields of the 25m Se^{83} and the 67s Se^{83} and a value of 0.27 per cent for the 67s Se^{83} was determined, assuming a yield of 0.21 per cent for 25m Se^{83}. The total fission yield of Br^{83} is then, 0.48 per cent.

A new Se activity of 17.5 $\pm$ 0.3 sec. half-life was discovered in the course of this work. It appears to decay by emission of γ radiation of ~150 Kev. The cross-section for formation of this activity is the same order as that of the 17m Se, ~0.6 barns.

The presence of the 67s Se^{83} activity decaying by β^- emission to 2.4h Br^{83} resolves the difficulty of the apparently high "independent" yield of Br^{83} in fission.

The presence of a short-lived state of Ge^{77} decaying by β^--emission to 40h As^{77} has been shown by As extractions of Ga sulfide solutions irradiated with neutrons. The cross-section for formation of the short-lived state was found to be about 10 per cent larger than that of the 12h Ge^{77}. A short-lived Ge activity was found by irradiating GeS_2 with neutrons for 20 sec. and measuring the activity through Al absorbers. The half-life was determined to be 59 $\pm$ 2 sec. and the β energy, 2.8 Mev. The agreement between the cross-sections of the 59s Ge and the 40h As^{77} from the short-lived Ge^{77} makes it probable that the 59s Ge is genetically related to the 40h As^{77}.

The presence of the 59s Ge^{77} activity decaying by β^- emission to 40h As^{77} resolves the difficulty of the apparently high "independent" yield of As^{77} in fission.

MDDC - 838 The Average Gamma Energy Emitted per Beta Particle for Several Radioactive Isotopes, by E. C. Barker, 8 p., April 2, 1947.

On the basis of certain assumptions it was shown by Gray that the γ-ray energy absorbed in any medium is related to the ionization produced in a gas filled cavity in that medium in the following manner:

$$E_v = J_v \; W \; \rho$$

where E_v is the γ-ray energy absorbed per unit volume of the media J_v is the ionization per unit volume produced in the gas
W is the average energy lost by the secondary electrons per pair of ions formed in the gas
ρ is the ratio of the stopping power of the medium and the gas for the secondary electrons.

Gray shows that ρ is practically constant over a large range of electron energies and that its value is 1,870 for aluminum.

In this experiment, a method similar to Gray's is followed for radioactive isotopes of Na^{24}, Au^{198}, and Ga^{72}.

Using an effectively infinite medium of aluminum and small ionization chambers to measure the number of ion pairs produced per second at various radii from the source, the average γ energy emitted by the source per β-particle is

$$Q/\beta = 4\pi W \rho . \int_0^\infty \underline{n}_r \underline{r}^2 \underline{dr}$$

where W is the average energy lost by the secondary electrons per ion pair formed in air, ρ is the ratio of the rate of loss of energy by the secondary electrons in the medium and in air $\underline{n}_r$ is the ionization per unit volume produced in a small air-filled cavity at a distance $\underline{r}$ from the source. The measurements required are of (1) ionization current, (2) volume of the ionization chamber. (3) source strength in terms of β-particles per second, (4) chamber position.

Two separate sources were made of each isotope investigated. The results are tabulated below:

Sample	Form	β Strength	k	Q/β
Na - 1	NaF	1.31×10^{10}	1.12	4.15 Mev
Na - 2	NaF	1.37×10^{10}	1.11	4.19 Mev
Au - 1	Au Foil	1.608×10^{10}	1.11	0.369 Mev
Au - 2	Au Foil	6.62×10^{10}	1.13	0.364 Mev
Ga - 1	Ga_2O_3	1.248×10^{10}	1.10	2.61 Mev
Ga - 2	Ga_2O_3	1.969×10^{10}	1.13	2.72 Mev

MDDC - 839 A Fast Coincidence Circuit With Pulse Height Selection, by P. R. Bell, S. DeBenedetti, and J. E. Francis, 8 p , n.d., decl 4/22/47.

The output signal of a linear amplifier may have a rise time of $1 - 2 \times 10^{-7}$ seconds. Therefore, the output of a pulse height selector operating on this signal has a variation of delay from the original signal of about this amount. Since this delay depends on the pulse height, the pulse height selector output is unsuitable for fast coincidence work. In the instrument to be described this difficulty is largely removed by feeding the amplifier signal into two separate channels: the first is a pulse height selector which produces a rectangular pulse (gate) longer than the amplifier signal when this signal height falls between two adjustable limits of voltage; the second channel limits, differentiates and delays the amplifier signal so that it falls within the "gate" duration. The pulses from the two channels are fed to a coincidence circuit whose output reproduces the constantly delayed and sharpened amplifier pulse only when the gate pulse is presented. This scheme has been employed to obtain simultaneous or delayed coincidences between pulses (with a height falling between two specified limits) from one chamber, and pulses greater than a known height from a second counter. The resolving time is approximately .4 microseconds.

MDDC - 840 Radioactive Isotope Tracer Techniques, by G. E. Boyd, 11 p., March 19, 1947.

An outline for an oral presentation of a paper on Radioactive Isotope Tracer Techniques invited by the Division of Industrial and Engineering Chemistry of the American Chemical Society for their Symposium on Bench-Scale Equipment and Techniques. Text and illustrations are not included.

MDDC - 841 Meterological Equipment of the Hanford Engineer Works by P. E. Church and C. A. Gosline, Jr. 8 p.,n.d., decl. 4/17/47

A 400 ft. tower with an anemometer and an aspirated thermohm at each 50 ft. interval and a precision wind vane at each 100 ft. interval with indicators and recorders in the office building is described. With a "surface" observation level the lapse rate, hence degree of stability, is continuously recorded at nine levels; the character of mixing and amount of dilution of waste stack gases is thereby known.

MDDC - 842 Neutron Diffraction Analysis of NaH and NaD, by W. L. Davidson, G. A. Morton, C. G. Shull, and E. O. Wollan, 12 p., n.d., decl. 4/28/47. (See also MDDC-804)

The crystal structure of NaH and NaD was unambiguously established as being the NaCl type rather than ZnS. The coherent scattering cross-section of hydrogen was found to be between 2.0 and 3.0 barns, given a scattering wave 180° out of phase with that of sodium. The coherent scattering cross-section for deuterium was found to be between 2 and 3 barns, and to be in phase with the scattering of sodium. The background intensity and angular dependence indicated that the hydrogen and deuterium atoms behaved as though they were almost free atoms.

MDDC - 843 Phase of Scattering of Thermal Neutrons by Aluminum and Strontium, by E. Fermi and L. Marshall, 2 p., February 1947. (See also Physical Review, Vol. 71, p. 915, June 15, 1947)

In a previous paper MDDC-55, a method was described for determining whether neutrons scattered by an atom have the same phase as the primary neutron wave or opposite phase. The method has now been applied to two more elements, Al and Sr. The crystals investigated were Al_2O_3 (corundum) and $SrSO_4$ (celestite). The measured intensities of various orders of Bragg reflections of monochromatic neutrons are given in a table, which is arranged like Table I of the paper quoted.

Attempts to fit these data with actual values of the scattering length for aluminum and strontium have not been satisfactory. It seems unambiguous, however, that the sign of the scattering of aluminum is the same as that of oxygen, namely positive,

A similar behavior of the reflection from the 101 plane of celestite indicates that the scattering length of strontium is also positive. From the scattering cross sections of these two elements, 1.4×10^{-24} cm^2 for Al and 9.5×10^{-24} for Sr, one can calculate the scattering lengths $.35 \times 10^{-12}$ cm for Al and $.88 \times 10^{-12}$ cm for Sr.

MDDC - 844 Spin Dependence of Scattering of Slow Neutrons by Be, Al, and Bi, by E. Fermi and L. Marshall, 9 p., n.d., decl. 4/30/47. (See also Physical Review, Vol. 72, p. 408-410, September 1, 1947.)

Some information has been obtained on the spin dependence of scattering of slow neutrons by Be, Al, and Bi by measuring the scattering cross section for filtered neutrons. The result is that in none of these three cases does the sign of the scattering length change when the spin orientation is changed. But in the case of Be and Bi the magnitude of the scattering length for one spin orientation may be up to twice as great as that for the other spin orientation, and in the case of Al the variation may be by a factor of 3.

MDDC - 845 Scattering of Neutrons in Polycrystals, by R. J. Finkelstein, 17 p., n.d., decl. 4/16/47. (See also Physical Review, Vol. 72 p. 907-913, November 15, 1947)

Although elastic and first order inelastic cross sections for a neutron against a Debye crystal have already been determined, expressions for higher order inelastic collisions have not been calculated, and would be very complex for the Debye model. The calculation of the total inelastic cross section involving the emission of an arbitrarily large number of photons is presented for a neutron against an Einstein polycrystal. The result, as one would expect, is essentially the same as that given by Fermi for amorphous scatterers, except at high neutron energies where the cross section is calculated for the ejection of the struck nucleus from its lattice. The coherent elastic cross section is also determined; it is important for energies as high as 1 volt, and does not differ appreciably from that previously calculated for a Debye crystal. The total cross section, the sum of the coherent and incoherent parts, is compared with the experimental data on beryllium.

MDDC - 846 The Slowing Down of Neutrons in Air, by D. H. Frisch, 14 p., n.d., decl. 1/8/47. (LADC-259)

The total neutron cross sections of nitrogen and oxygen have been measured from 35 Kev to 750 Kev in a good geometry scattering experiment. The slowing-down lengths from 850 and 350 Kev to the indium resonance at 1.44 ev, derived from the observed cross sections on the assumption of isotropic scattering in the c.g. system, are $2.58 \times 10^4 \pm 10\%$, and $2.12 \times 10^4 \pm 10\%$, respectively, in dry air of density 1 mgm/cm^3 and oxygen content 20%. As an independent check, the distribution of indium resonance neutrons in a large liquid air bath has been studied experimentally and matched by a distribution calculated using the standard age theory approximation. The slowing-down lengths in liquid air thus obtained are $2.26 \times 10^4 \pm 10\%$ and 1.96×10^4 cm $\pm 10\%$ for the same energies.

MDDC - 847 Determination of Anodic Current Efficiency in the Counter flow Electrolysis of Uranyl Chloride Solutions by W. J. Hamer, 20 p., n.d., decl. 4/16/47.

Anodic current efficiency or the chlorine-oxygen ratio in the electrolysis of aqueous solutions of uranyl chloride was determined by a counterflow method at temperature of 25°C. Because of the hydrolysis of dissolved chlorine, measurements were made only after sufficient time had elapsed to assure a state of equilibrium. Different concentrations of electrolyte, various electrode materials, and several current densities were employed to ascertain the effects of such changes. The standard potentials of the oxygen and chlorine electrodes are such that oxygen should be evolved at anodes in the electrolysis of chlorides. However, chlorine is liberated because of the relative magnitudes of the oxygen and chlorine overvoltages. The value of overvoltage is dependent of the electrode material and the nature of the electrode surface. For uranyl chloride the current efficiencies increase in the order: magnetite, arc carbon, graphite, tungsten carbide, columbium-tantalum carbide, zirconium carbide, palladium, palladium black, platinum, platinum black, platinum-iridium alloy, and iridium with the last six giving about the same efficiency. Magnetite, the carbides, arc carbon, and graphite erode or pencil during electrolysis. Palladium black and platinum black become dispersed in the electrolyte. The highest current efficiency obtained was 97 percent and the data indicated that current efficiencies of 100 percent cannot be realized for aqueous solutions of uranyl chloride at 25°C. The method is general and may be used in the determination of the current efficiency of many electrode processes.

MDDC - 848 Protection of Laboratory Personnel Handling Radioactive Materials, by L. H. Hempelmann, 12 p., n.d., decl. 4/23/47. (LADC-395)

This report consists of a short outline of material and graphs to be presented in a 20 minute talk at the Symposium of Isotopes of the Conference on Metabolic Aspects of Convalescense, sponsored by the J. Macy, Jr. Foundation in New York on March 31, 1947.

The outline consists of the following:

I. The present status of the "tolerance dose" of ionizing radiation.

(a) The discussion of the "tolerance dose" to be based chiefly on the declassified papers of Lorenz, Jacobson Henshaw and Prosser, which were presented on December 2, 1946 at the Radiological Society of North America.

(b) Methods of calculating radiation dosage from radioactive materials taken into the body to be discussed with emphasis on the sources of error of such calculations. No classified information or exhibits to be presented.

II. The diagnosis of early radiation injury.

(a) The inadequacy of present methods of diagnosing early radiation damage to be discussed as outlined in the declassified paper of Jacobson.

(b) Three previously classified graphs showing the blood changes of persons acutely exposed to large doses of ionizing radiation to be shown.

(c) The previously classified observations at Los Alamos Scientific Laboratory of the increase in refractile neutral red bodies in the lymphocytes of persons chronically and acutely exposed to ionizing radiation to be presented, the discussion to center around eight charts and graphs.

MDDC - 849 Neutron Polarization by D. J. Hughes, J. Wallace, and R. Holtzman, 3 p., n.d., decl. 4/22/47.

The production of polarized neutrons by passage through magnetized iron, has been treated theoretically by Halpern and Holstein and experimentally by Bloch, Hammermesh, and Staub, Fryer, and others. With the availability of intense neutron beams from the Argonne deuterium-moderated pile, it is now possible to investigate the polarization process in more detail than could be done in the earlier experiments. A series of measurements have been made on neutron polarization to study the process itself, as well as to develop methods for the production of strongly polarized neutron beams for experimental use. The polarization produced by transmission through magnetized iron is measured by the excess transmission of the iron when magnetized compared to that when unmagnetized. The relative increase in transmission effect has been measured for thermal neutrons as a function of magnetizing fields up to 11,000 oersteds, of thickness of iron up to 6 cm, and for different kinds of iron and steel. Values of E up to 30% have been obtained representing the production of polarized beams in which 83% of the neutrons are aligned in one direction (polarization of 64 percent). The results lead to a value of the polarization cross-section, p, which is much larger than that calculated by Halpern, Hammermesh & Johnson and also that observed experimentally by Bloch et al. The polarization for monenergetic neutrons has also been studied, using a mechanical velocity selector and neutron filters; the complete disappearance of polarization of neutrons of wave length greater than 1.04 A has been demonstrated.

MDDC - 850 Low Temperature, High Pressure Data of State for Hydrogen and for Deuterium between 64 and 300°K, by H. L. Johnston, et al., 29 p., n.d., decl. 4/3/47.

An apparatus has been devised for the accurate measurement of high pressure gaseous data of state from temperatures attainable with liquid hydrogen up to room temperature. The apparatus consists of a thick-walled copper pipette of approximately 25 cc volume suspended in a vacuum space and surrounded by a radiation shield, in the manner of a vacuum calorimeter assembly. The high pressure pipette valve is mounted in an "auxiliary block" at a temperature close to that of the pipette. Temperature is read (to 0.01°) by means of calibrated thermocouples and pressure (to 0.1 lb per square inch) by means of a dead weight pressure gauge.

The gas is expanded into a water burette of the type used by Bartlett, in order to determine the quantity of gas held in the pipette.

Isothermals have been determined, with this apparatus, for hydrogen and for deuterium between 64° and 300°K and between 20 and 200 atmospheres. Plots of PV versus P for twelve isotherms of hydrogen and twelve of deuterium yield smooth curves accurate to 0.1 of 1%.

MDDC - 851 Pyrolysis Method for Detection of Traces of Fluorocarbons in Air, by S. S. Kirslis and E. Staple, 7 p., n.d., decl. 3/9/47. (A-3603).

A rapid method for detecting slight traces of fluorocarbons in air was developed. The method is based on the pyrolysis of fluorocarbons to fragments which, on reaction with water, form HF which is detected by the color change of thorium-alizarin or zirconium-alizarin impregnated paper. The pyrolysis takes place in a platinum tube about 0.32" in diameter and 8 3/4" long, with two 1 3/4" long platinum contact sheets folded inside into a star-shaped cross section. The tube is heated to a bright red heat, about 950°C. The sensitivity of the test is sufficient to detect 1 p.p.m. of C_8F_{16} by weight in air in less than 1 minute, or 100 p.p.m. in 10 seconds.

MDDC - 852 The Specific Activity of Radium by T. P. Kohman, D. P. Ames, J. Sedlet, 33 p., March 15, 1947.

The specific alpha activity of radium has been determined by counting the alpha particles emitted by aliquots of weighed radium chloride samples in a high-speed parallel-plate ionization chamber of known counting yield. A special method was devised to correct for the alpha activity of radon and its daughters, which had previously been the chief deterrent to the use of this direct method for radium. The measurements yielded a specific counting rate of $1.1148 \pm 0.0059 \times 10^{12}$ counts per minute per gram of radium. Taking the counting yield as 0.515 ± 0.003, this corresponds to a specific activity of $3.608 \pm 0.028 \times 10^{10}$ alpha disintegrations per second per gram and to a half-life of 1622 ± 13 years.

MDDC - 853 The Effects of Radiation on Hemopoiesis, by J. S. Lawrence, A. H. Dowdy, and W. N. Valentine, 28 p., March 1, 1947.

In a consideration of radiation effects on hemopoiesis the following facts are considered fundamental. (1) There is little evidence that the morphological constituents of the peripheral blood are appreciably affected except by very large amounts of radiation. (2) The peripheral blood picture resulting at any given period after radiation is greatly influenced by the length of life or rate of utilization of the different morphological elements in the peripheral blood. (3) The effect of radiation on the peripheral blood is influenced by the radiosensitivity of the various parent cells of the peripheral elements. (4) The ability of the various tissues to regenerate is of great importance.

With these basic considerations in mind, the effects of radiation are discussed under the following divisions.

1. Single dose to the body as a whole.
2. Changes in morphology of the hemopoietic tissues in rats given single doses of Röentgen radiation.
3. Repeated small doses to the body as a whole.
4. Single or repeated doses to one area of the body.
5. Internal radiation.
6. The effect of neutrons.
7. The effect of total body radiation on coagulation of blood and hemorrhagic manifestations.
8. Effect of radiation on man.

MDDC - 854 Apparatus for Rapid Analysis of Boron 10 by J. L. McKibben, n.d., decl. 1/23/47; 6 p.

An apparatus employing a proportional counter for rapid analysis of boron 10 or any strong slow-neutron-absorbing element is described. A typical calibration curve is shown.

A drawing of the instrument is included.

MDDC - 855 Four New Methods of Industrial Gas Analysis, by H. D. Middel, 11 p., September 1946.

The majority of the gas analyzers commercially available use thermal-conductivity, infrared, ultra-violet, mechanical-Orsat, combustion, or selective-diffusion methods. These are physical methods of analysis based upon some physical property of the gas and so the instruments are not true analyzers. Magnetic-susceptibility, ionization-potential, and vapor-pressure methods tend to be specific analyzers. The gas spectroscope and the mass spectrometers, in the absence of fragmentation and multiple ionization, are true analyzers. A new instrument, the acoustic gas analyzer, differs from other physical types only in principle of operation and detail. It is not a true analyzer.

A discussion of the following instruments is given: acoustic gas analyzer, spectrometers (analytical type mass spectrometer, process spectrometer, and leak detector), dewpoint recorder, and X-ray photometer.

MDDC - 856 The Addition of Methyl Alcohol to Fluoroethylenes, by W. T. Miller, Jr., E. W. Fager, and P. H. Griswold, 6 p., n.d., decl. 4/11/47.

In investigating the addition reactions of fluorinated ethylenes, it was found that perfluoro- and chloroperfluoroethylenes exhibited marked general electrophilic reactivity and were readily attacked, for example, by such typical nucleophilic reagents as amines and alcoholates. Such reactions offer wide possibilities for the synthesis of fluorine containing compounds. This preliminary paper reports the base catalyzed addition of methyl alcohol to tetrafluoroethylene, chlorotrifluoroethylene, and unsym.-dichlorodifluoroethylene.

MDDC - 857 Radioactivities Produced in Neutron Irradiation of Chlorine, by R. T. Overman, 6 p., n.d., decl. 4/23/47.

C. P. potassium chloride was placed in the Clinton pile and bombarded for long periods (12 to 18 months).

The experiments are described. The results are summarized in the table below. The confirmed values are in parentheses.

Reaction	Half-life	Beta Energy (al. Abs.) Mev
Cl (n,γ)Cl	1 x 106 years	0.66
Cl (n,γ)Cl	(37 minutes)	complex
Cl (n,p)S	(87 days)	0.17
Cl (n,γ)P	(14.7 days)	(1.7)

MDDC - 858 Vacuum Sparking Potentials under Surge Conditions, by W. Parkins, 10 p., February 18, 1946. (RL-7.6.44).

For the equilibrium condition after prolonged sparking of outgassed electrodes, the critical-peak electric field varied from 1.5 to 0.8 million volts per cm for tungsten and from 1.0 to 0.4 million volts per cm for copper. This variation was a result of peak voltage variation from about 30 to 90 kv.

An explanation of the spark breakdown under these conditions is given.

In design of an electrode system to support the largest peak fields without sparking, the important consideration is the condition of the electrode surface and not the tank pressure for operation below 10^{-3} mm Hg. Outgassing, smoothness and material of the electrode determine these surface conditions.

MDDC - 859 Cobalt 61 Radioactivity, by T. J. Parmley and B. J. Moyer, 1 p., March 28, 1947. (BP-66) (See also Physical Review Vol 72 p. 82, July 1, 1947).

Isotopes of Ni^{61} and Ni^{62} were subjected to fast neutron bombardment from the Crocker Laboratory Cyclotron. Among the activities produced was a 1.8 hour half-life associated most strongly with the Ni^{61} sample. Chemical extractions showed this activity belonged to cobalt.

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The mass assignment was established as follows: (1) Electrolytic copper was activated with fast neutrons. The cobalt extractions yielded a 1.8 hour half-life activity. Calutron analysis of the copper placed this activity in 61 mass position. (2) Nickel was bombarded with 22 Mev deuterons followed successively by cobalt separation and calutron analysis. The 1.8 hour activity appeared in 61 mass position.

An isotope Ni^{64} was bombarded with 14 Mev protons from the 37-inch cyclotron with the activity appearing in the cobalt extraction as $Ni^{64}(p,\alpha)$ reaction.

Absorption measurements in aluminum gave a maximum β energy of about 1.1 Mev with no indication of a gamma-ray.

MDDC - 860 Cloud Chamber and Magnet Assembly with Structural Frame and Heat Exchange One Quarter Size, by Radiation Laboratory, University of California, 1 p.. n.d., decl. 4/21/47.

An engineering drawing of the assembly

MDDC - 861 Cloud Chamber Camera Lights Assembly, by Radiation Laboratory, University of California, 1 p., December 19, 1946.

An Engineering drawing of the assembly.

MDDC - 862 Cloud Chamber, Heat Shielding, Magnet Shielding. Drawing #2c7145, by Radiation Laboratory, 1 p., December 20, 1946.

Instrument diagram.

MDDC - 863 Film Prog. 39, Film Prog. 18, Film Prog. 41, by Radiation Laboratory, 4 p., n.d., decl. 4/23/47.

This report consists of three photomicrographs. The plates were placed inside the tank of the 184-inch cyclotron.

Film Prog. 18 was made from an Ilford nuclear research plate exposed to high speed particles accelerated by the cyclotron.

Film Prog. 39 was made from an Eastman alpha particle plate exposed to high speed particles accelerated by the cyclotron. Deuterons = 40 Mev, α = 80 Mev.

Film Prog. 41 was made from an Eastman alpha particle plate exposed to beam of alpha particles of energy approximately 400 Mev.

MDDC - 864 New Observations on Two-Dimensional Condensation Phenomena, by S. Ross and G. E. Boyd. 7 p. n.d., decl. 4/11/47.

Tests of the reliability of the radio-isotope exchange method for the determination of the specific surface of a solid were made by comparing values so obtained with those found using the low pressure gas adsorption technique of Wooten and Brown (Journal of the American Chemical Society 65, p. 113, 1943) on the same solid. Incidental to this yet incomplete study, several new and possibly important observations were made.

Measurements of the adsorption of ethane at 91°K at low pressures on pure NaCl crystals showing only cube faces revealed the existence of a first order phase transition in the adsorbed film when p/Po = 0.043. The phase transition appeared to be complete when the amount adsorbed reached about 85% of a complete monolayer as estimated by the application of the BET equation to data taken in the relative pressure range, 0.05 to 0.30. When NaCl preparations exhibiting both (100) and (111) crystal faces were examined, two such transitions were found at: (a) p/Po = 0.043 and (b) p/Po = 0.035. An isotherm taken with a sample of pulverized NaCl also showed the two vertical portions now ascribed to the (100) and (111) surfaces and, in addition, a series of step-like vertical segments were found at still lower pressures.

Slow attainment of equilibrium was observed for the phase transition occurring on the (100) face.

MDDC - 865 The Structure of Uranium Hydride and Deuteride by R. E. Rundle. February 1947, 17 p. (See also Journal of The American Chemical Society, Vol 69, p. 1719-1723, July 1947).

Massive uranium powders and becomes hot in hydrogen. X-ray analysis first showed (1942) that the product was a true compound; the position of the metal atoms is unrelated to that of any of the forms of uranium metal. Chemical analysis has established the formula of the compound as UH_3[1].

The hydride has a simple cubic lattice, a = 6.6310 ± 0.0008A, ρ = 10.92 g./cc, z = 8. There are two equivalent uranium atoms at 000, $\frac{1}{2}\frac{1}{2}\frac{1}{2}$, and six equivalent atoms at ($\frac{1}{4}\frac{1}{4}$0) (0$\frac{1}{4}\frac{1}{4}$) ($\frac{1}{4}$0$\frac{1}{4}$)($\frac{3}{4}\frac{1}{4}$0) ($\frac{1}{4}$0 3/4) (0 3/4$\frac{1}{4}$). The space group is O_h^3, O^2 or T_d^4. Since the hydrogen atoms contribute nothing to the scattering the space group remains in doubt.

Precision measurement of the lattice indicates that there is no appreciable solution of hydrogen or uranium in the hydride phase. The deuteride has a somewhat smaller spacing than the hydride.

MDDC - 866 Interpretation of the Triton Moment by R. G. Sachs, 18 p., n.d., decl. 4/30/47. (See also Physical Review Vol. 72 p. 312-320, August 15, 1947).

In order to account for the measured magnetic moment of the triton it is necessary to assume that the wave function in the ground state is a linear combination of ^2S, ^2P, ^4P, and ^4D functions. An attempt is made to determine the amplitudes of these functions from the magnetic moment on the assumption that the intrinsic nucleon moments are additive and relativistic effects are negligible. With certain reasonable assumptions concerning the nature of the wave functions, it is found that the relative probabilities for finding the system in the ^2P, ^4P, and ^4D states satisfy the relation shown by the curves. If it is assumed that the amplitude of the ^2S state is as large as possible, the wave function contains no ^4D state, 8% ^4P state, and 17% ^2P state. A wave function of this form would

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seem to indicate that there are three-body forces acting between nuclear particles. In the other extreme case that the wave function contains a maximum of the ^4D function, the ^2S state probability is zero, the ^4D probability is 22%, the ^4P is 30%, and the ^2P is 48%. If the wave function of He^3 has the same form as that of H^3, the He^3 moment would be expected to lie on one of the curves shown by a graph.

MDDC - 867 Production And Properties Of 50-Year Element 94, by G. T. Seaborg, et al. March 20, 1942. 11 pgs. (See also Physical Review, Vol. 69, p 366-367, 1946)

Element 94 has been found to grow in the 93 fractions isolated from uranium after deuteron bombardment. It is the daughter of 2.0-day 93^{238}. Aluminum absorption indicates that the decay beta-particles have an energy of about 1.0 Mev., and lead absorption measurements show the presence of 1.1 Mev gamma-rays. By following the decay schemes it is possible to establish the half life of 93^{238} despite the 93^{239} which is present. That the alpha activity is due specifically to the daughter 94^{238} is shown by the chemical separation. Air and Al absorption of the alpha particles have been measured; both measurements gave as the (extrapolated) range in air (15°C/760 mm) of the alpha particles an average value of 4.1 ± 0.1 cm. A half-life for 94^{238} of 50 years is believed to be accurate to within a factor of 2.

MDDC - 868 Resonance Scattering Of Neutrons By Mn^{55}, by F. G. P. Seidl et al. March 24, 1947. 13 pgs.

Evidence has previously been obtained that manganese has a strong neutron scattering resonance in the neighborhood of its absorption resonance at about 250 ev. It is again demonstrated the large predominance of scattering over absorption by comparing "poor geometry" and "good geometry" transmission through a manganese foil. Using 0.024 gm/cm^2 manganese detectors aligned 200 cm behind a 0.0030 gm/cm^2 scatterer consisting of $MnSO_4$ dissolved in D_2O, the transmission of a neutron beam from the heavy water pile was observed. The beam had been filtered through enriched boron of thicknesses equivalent to 0.46, 0.78 or 1.10 gm/cm^2 B^{10}. Counting rates proportional to the transmission by pure D_2O were 1117.6, 493.5, 263.0 cpm, respectively for the above B^{10} filters. With the same amount of D_2O plus $MnSO_4$ 1062.1, 475.4 and 258.7, was obtained, the statistical error being 0.7%. The effective transmission cross-section was $1900 \pm 350 \times 10^{-24}$ cm^2 for the incident neutrons passed by 0.46 gm/cm^2 B^{10} and removed by 1.10 gm/cm^2 or passed and removed by 0.46 gm/cm^2 and 0.78 gm/cm^2 or 0.78 gm/cm^2 and 1.10 gm/cm^2. A numerical calculation indicates these data to be consistent with a peak scattering cross-section of 5000×10^{-24}cm^2 per atom. When counting rates due to more penetrating neutrons are not subtracted, lower effective cross-sections are obtained; this is evidence for higher resonances.

MDDC - 869 The Diffraction of Neutrons by Crystalline Powders, by C. G. Shull and E. O. Wollan, 16 p., n.d., decl. 4/28/47.

A study of the diffraction of neutrons by a number of substances was made using the powdered crystal technique. A monochromatic beam of neutrons (λ = 1.08 A) obtained from the Clinton Pile by reflection from a NaCl single crystal was passed through a flat plate of the crystalline powder to be studied and the scattered radiation was measured with a BF_3 counter enriched in B^{10}. In order to make the interpretation of the data as straightforward as possible, studies were made of a number of substances (CaO, CaC_2, CaS, graphite, diamond, etc.) which are nearly mono-isotopic and have zero-spin nuclei. The intensity of two or more diffraction peaks and the diffuse scattering were measured in each case. It was found that the ratio of the diffuse scattering cross-section to the coherent (Bragg reflection) cross-section varies from 0.5 for diamond to 9 in the case of CaS. Such large values for this ratio do not seem to be accounted for on the basis of present theory. Studies have also been made with substances containing nuclei which posses spin and examples of these are given.

A number of graphs and one photograph are included.

MDDC - 870 The Theory and Properties of Low Voltage Radiation Counters, by J. A. Simpson, Jr., 64 p., n.d., decl. 4/25/47.

On the basis of experiments which are described, conditions were found for adequate performance of low voltage radiation counters. The conditions considered are: criteria for establishing minimum threshold potentials for counters, and criteria for satisfactory operating characteristics of counters.

Using these criteria it was shown that neon with small amounts of argon added is at least one of the combination of gases which will successfully produce low voltage counters. The characteristics and applications of the neon-argon tubes are described.

MDDC - 871 Photo-Neutrons Produced in D_2O and Beryllium by Fission Product Gamma-Rays, by W. D. B. Spatz, D. J. Hughes, and A. Cahn, 9 p., n.d., decl. 4/22/47.

The production of photo-neutrons in deuterium and beryllium by the gamma-rays emitted by fission products of U^{235} has been studied. The U^{235} sample was shot from a position near the chain-reacting pile to a tube which was surrounded by a cylinder of deuterium or beryllium. The neutron energies were determined by standardization of the geometry with neutron sources of known energy. The intensity of photo-neutrons relative to delayed neutrons could be obtained; for deuterium the ratio is 0.28. Separation of photo-neutron from delayed neutron periods of the same order of magnitude is difficult. As a result the high energy short period gamma-rays were measured directly by obtaining absorption coefficients for each period in iron and lead, and the effect of the gamma-rays producing photo-neutrons was calculated. The gamma energies calculated from the measured neutron energies are in good agreement with those measured directly. Also the photo-neutron intensities calculated from the gamma intensities are in approximate agreement with the observed intensities. With a beryllium cylinder a large number of photo-neutron periods was observed, and the decay curve could not be broken down into discrete periods.

MDDC - 872 The Total Neutron Cross Section of Rhenium and Neodymium, by W. J. Sturm and G. Arnold, 6 p., n.d., decl. 1947.

The cross sections of rhenium and neodymium were examined briefly in the region of low neutron energies with lithium fluoride crystals. Rhenium shows a sharp resonance at 2.3 ev. The height of the peak was greatly lowered by the large resolution width (the energy spread being somewhat less than 0.75 ev at 2.5 ev) for which no correction has been made. A previous measurement of the energy of this level has been made so that the results of boron absorption measurements placed the resonance at 2.9 ev. The small maximum at about 0.5 ev is due to absorption of the second order neutrons by the strong resonance at 2.3 ev; the cause of the small peak at 5 ev is rather uncertain, and may be due to a slight amount of impurity in the sample measured. The samples were disks of the metal having surface densities varying from 1.5 to 11.5 gm/cm^2.

Neodymium was measured in the form of pressed pellets of Nd_2O_3 powder, with surface densities between 5 and 18 gm/cm^2. It was necessary to subtract 6.2 x 10^{-24} cm^2/atom, 3/2 the atomic oxygen scattering cross section in the calculation of the total cross section of the neodymium atom. The results are shown in diagram. A plot of σv (cross section x neutron velocity) against E shows a marked rise with energy, indicating a large scattering cross section or a strong resonance level at higher energy. The curve becomes nearly horizontal if a constant value of 15 x 10^{-24} cm^2/atom is attributed to scattering, thus making the absorption cross section at 0.025 ev about 92 x 10^{-24} cm^2/atom. Earlier measurements at a single energy gave the absorption cross section for kT neutrons at about 75 x 10^{-24} cm^2/atom.

MDDC - 873 Polarization of Neutrons in Different Materials, by J. R. Wallace, D. J. Hughes, and R. H. Holtzman, 3 p., n.d., decl. 4/22/47.

The production of polarized neutrons in magnetized iron is detected by the increase in transmission with magnetization. The single transmission effect, E, has been measured for thermal neutrons as a function of magnetizing fields, H, up to 12,000 oersteds, of thickness of iron up to 9 cm, and for different kinds of iron and steel. Values of E up to 100 per cent have been obtained representing the production of polarized beams in which 93 per cent of the neutrons are aligned in one direction (polarization of 86 per cent). The polarization is much greater in cold-rolled unannealed steel than in armco or Swedish iron which had been used by some of the early workers. Saturated polarization for small thicknesses of steel, d, is demonstrated by (1) proportionality of E to d^2 and (2) saturation with increasing H. The saturated polarization gives the polarization cross section p directly. The value is in agreement with that derived from the experiments with armco iron (See MDDC-849). A single transmission effect has also been observed for nickel with a magnitude which indicates a polarization cross section for nickel of about 30 per cent of that of iron.

MDDC - 874 The Critical Ionization Potentials of Uranium Hexafluoride and Hydrogen Fluoride, by J. R. White and A. E. Cameron, 2 p., n.d., decl. 4/21/47. (See also Physical Review Vol. 71 p. 907, June 15, 1947).

The critical electron energies necessary for the formation of ions in uranium hexafluoride and hydrogen fluoride vapor were found to be: UF_5^+ 15.5 volts; UF_4^+ 20.1 volts; UF_3^+ 23.5 volts; UF_2^+ 29.9 volts; UF_1^+ 37.9 volts; U^+, 50.3 volts; HF^+, 5.4 volts.

Determinations were made using a VGIA ion gage.

MDDC - 875 High Energy Alpha Particles Associated with Fission, by E. O. Wollan, C. D. Moak, and R. B. Sawyer, 10 p., July 1944. (See also Physical Review Vol. 72 p. 447-451, Sept. 15, 1947).

The photographic emulsion technique was applied to the study of the long range particles given off during neutron irradiation of uranium. Plates soaked in uranyl acetate solutions and exposed near the edge of the reflector of the Clinton Pile gave of the order of 10^6 fission tracks on a 3" x 1" plate. In all cases in which both ends of the alpha track are observed to lie in the emulsion, it was found that the alpha particle originates near the center of the fission track.

Alpha particle tracks were distinguished from proton tracks by the relative grain spacings along the tracks. Because alpha particles originate near the center of the fission track, there is a possibility that they may be ejected from one of the fission fragments left in a highly excited state.

From literature, the stopping power of the plates relative to air is about 1400. On this basis the energy of the particles was calculated and an energy distribution curve was plotted. The distribution in length of the normal fission tracks (total tracks) is also plotted.

MDDC - 876 An Upper Limit for the Cross Section for Scattering of Neutrinos by Hydrogen, by E. O. Wollan, 3 p., May 1947. (See also Physical Review, Vol. 72, p. 445-446, Sept. 15, 1947).

An upper limit of about 2.0×10^{-30} cm^2 for the cross section for scattering of neutrinos by hydrogen has been determined. The experiment consisted of an attempt to measure the ionization in hydrogen in the vicinity of the Clinton Pile under as nearly ideal shielding conditions as possible. The fact that the ion current in the hydrogen filled chamber could not be measured and the known sensitivity of the instrument was used to deduce the above mentioned upper limit to the cross section. One reason for making this determination was to rule out the possibility of neutrinos constituting a possible health hazard in the vicinity of a high flux pile.

MDDC - 877 Thin Window Counter with Special Mica to Glass Seal, by C. S. Wu, C. L. Meaker and H. A. Glassford, 15 p., n.d., decl. Jan. 13, 1947 (See also Review of Scientific Instruments, Vol. 18, p. 693-695, Oct. 1947).

A thin window counter with special mica to glass seal was developed, especially for the detection of low energy electrons from radioactive isotopes such as C^{14}. It is simple to construct and has proved to be vacuum tight. It can be operated without external quenching and exhibits flat plateaus of 100 to 300 volts. The average useful life of these counters is around a year or more. The efficiency of the counters is very satisfactory.

Photographs of the counter are included.

MDDC - 878 The Number of Neutrons Emitted by Ra + Be Source, Source II - Experiments in a Water Tank, by H. M. Agnew, et al., 9 p., September 7, 1942. (CP-252).

The number of neutrons emitted by a Ra + Be source was measured by integrating the thermal neutron activity of a standard detector in a water tank. It was found that the number of neutrons emitted by Source II (10 gms of Be mixed with 1 gm of Ra) is 14.0×10^6 neutrons/second.

Two photographs of the apparatus used are included.

MDDC - 879 The Absolute Measurement of Thermal Neutron Density, by H. L. Anderson, P. G. Koontz, and J. H. Roberts, 6 p., August 7, 1942. (CP-226).

A method for determining the absolute value of the thermal neutron density is described. For measurements in a beam of thermal neutrons, a boron trifluoride proportional counter filled with a known amount of BF_3 gas is used. For measurements inside a medium in which thermal neutrons are diffusing, MnO_2 detectors are used. These detectors were standardized against this BF_3 counter in a slow neutron beam. For the MnO_2 detector which was used (1.05 grams on an area 5 x 6 cm^2 enclosed in scotch tape and measured by wrapping around a 0.011 cm wall dural counter), the number of neutrons per second per cm^2 traversing the detector is 0.76 x the saturation activity of the detector in counts per minute.

MDDC - 880 The Number of Neutrons Emitted By A RA-BE Source (Source I) by H. L. Anderson, et al. March 21, 1942., 9 p.

Equipment and procedure used to determine the number of neutrons emitted by an Ra-Be source is described. The calculated value arrived at from the data is 14.36×10^6 neutrons per second.

MDDC - 881 Acute Radiotoxicity of Injected P^{32} in Mice. Part I. Metabolism and Survival, by D. S. Anthony and R. H. Snyder. 17 p., February 11, 1947. (C-3772).

The results of pilot experiments on the metabolism and radiotoxicity of radioactive phosphorus are reported in the paper.

Data were obtained on the toxicity of a well-known radioactive element in the same strains of animals and under the same experimental conditions as data obtained with less familiar radioactive elements. Determinations of the relative radiotoxicity of different isotopes could therefore be made without reference to work done under different conditions.

Since the effects of radioactive phosphorus on man had been studied, comparison of these effects with those on laboratory animals provided a basis for extrapolation with other radioactive elements.

The experiments with radioactive phosphorus greatly facilitated planning and interpretation of later experiments on the toxicity of other heretofore rare radioactive elements.

MDDC - 882 Alpha Air Monitoring System, by Argonne National Laboratory, 2 p., March 2, 1946.

This system is used for collecting and detecting airborne alpha emitters. A known volume of air is drawn through a special filter paper and the alpha contamination collected is measured on a proportional counter. The apparatus is thus made up of units, a collecting unit and a detecting and counting unit.

The collecting unit, Mark 10 Model 35, consists of 3 components, the collector, flowmeter, and motor. The collector is a split-cylinder built to hold filter paper across the diameter so air enters on one side and is drawn out the other. The filter paper is a waterproofed asbestos fiber type made specifically to collect very small particles. The flowmeter is a shop made and calibrated unit used to determine the rate of flow of air through the filter paper. The motor is a Filter Queen vacuum cleaner motor modified by adding the necessary mounting fixtures and a rheostat to control the motor speed.

The counting unit, Mark 10 Model 36, is made up of a C17M10C air proportional counter unit, a mechanism for holding the counter and placing the filter paper in correct relation to it, and the scaling system. Voltage for the proportional counter is furnished by an electronically regulated supply variable from 1500 to 2500 volts positive. Pulses from the counter are amplified through a two tube negative feedback amplifier with a gain of 300 and a frequency response down 3 decibels at 20,000 and 1,500,000 cycles per second. The 6SN7 pulse-height selector also acts as an input system to the Higinbotham type scale of 64. The output system is adjusted to drive a Wizard EC84 impulse register.

A diagram of the system is included.

MDDC - 883 High Intensity Beta-Gamma Instrument, Mark 2, Model 10, Betty Snoops, by Argonne National Laboratory, 2 p., Nov. 13, 1945.

This instrument consists of a 20 cc ionization chamber, on a probe and a suitable amplifier with four ranges having respectively 0.2, 2.0, 20 and 200 roentgens per hour of gamma radiation for full scale deflection. The circuit is shown in diagram. It consists of a single stage amplifier using two Victoreen V32 triodes, and has a voltage sensitivity of 0.25 volts for full-scale deflection on a 20 microampere meter. In order to reduce the time for the needle to reach equilibrium from several minutes to several seconds a feedback circuit using a Victoreen V124 tetrode is employed. As may be seen from the circuit diagram when the input switch is in the "set" position no ionization current flows through the input resistors and thus the zero of the instrument can be adjusted in a radiation field. The sensitivity is changed by switching in different input resistors.

The switch, input resistors, and input tube are housed in a brass cylinder at the end of which is the ionization chamber. A cable about six feet long contains the wires for the voltages applied to the tube and the ionization chamber. This cable is attached to a battery box containing the batteries, the two other tubes, the on-and-off switch, the zero-set control, the sensitivity control and the microammeter. The instrument may be used with or without the cable.

The ionization chamber is made of lusteroid and is sufficiently thin to permit beta rays to enter it. These beta rays can be excluded by placing a lucite tube over the chamber. The instrument has been found useful for measuring intense radiations in inaccessible places. Weight about 8 lbs.

MDDC - 884 An Integration Radiation Meter For Beta And Gamma Rays, Sigmion, Mark 10, Model 70, by Argonne National Laboratory, 2 p., July 17, 1946.

The instrument consists of a 50 cc ionization chamber and an electronic circuit which is so constructed that when the total amount of gamma radiation falling on the chamber reaches any selected value up to 20 mr an alarm rings, the circuit is reset, and is again ready to operate. Each time the circuit is reset a message register is operated so that the total amount of radiation falling on the ionization chamber in any length of time can be measured.

The circuit as shown in the diagram uses a Victoreen V32 tube in an inverted manner so that the normal plate is the control grid and the normal grid is the plate. When used in this manner the effective grid currents are of the order of 10^{-14} amperes and do not vary appreciably with effective grid potential. These grid currents are balanced out by an adjustable uranium rod suitably placed in the ionization chamber. The instrument is self-contained with a battery life for continuous use of approximately 3 months. A cap is provided which may be placed over the ionization chamber to exclude beta particles from entering it. This instrument has been found useful for determining the integrated amount of radiation present in any locality. Weight about 15 lbs.

MDDC - 885 Quartz Fiber Microbalance, Argonne National Laboratory, 3 p., n.d., decl. 1/13/47.

The entire text of the report is given here.

This microbalance indicates by a calibrated dial and vernier the amount of torsion necessary to bring the known and unknown weights into balance. One division on the vernier is 6×10^{-9} grams. The maximum load per pan is about 20 milligrams.

The suspension or torsion fiber, beam, and pan holders are of fused quartz construction. The suspension fiber is about 2.3×10^{-3} centimeters in diameter. Two small platinum pans hold the materials to be weighed. The unknown is balanced as closely as possible with known weights. In balancing the oscillation of the beam damps out within 2 to 3 seconds. Then, one end of the suspension fiber is rotated until the balance is perfect. The amount of rotation is indicated on the dial and vernier.

An optical system is used for observing exact balance. Two lamps with exactly centered filaments throw onto prisms the images of two segments of the index fiber. This index fiber is above the beam and parallel to it. The segments chosen for viewing are near the ends of the beam. Through a system of reflecting and combining prisms the images of the index fiber are shown on a viewing screen for rough balance and may be viewed through an objective lens for exact balance. When viewing the balance through the objective lens, one sees a magnified image of the vernier in the left upper third of the field.

The accuracy is limited by temperatures changes and by vibration. Temperature changes are minimized by a set of 3 housings with dead air spaces between them. For extreme accuracy, the instrument should be used in a temperature controlled room. Two photographs of the instrument are given.

MDDC - 886 Ryerson Pocket Meter, by Argonne National Laboratory, 4 p. June 26, 1946.

The Ryerson Pocket Meter is a hermetically sealed condenser type ionization chamber about the size and shape of a fountain pen, designed to be worn as a personnel monitoring device for X and gamma radiation.

In order to properly serve the above function, a device of this type must meet certain rigid qualifications as follows: (1) sensitivity, the ability to measure within 10% accuracy, 100 milliroentgens, (2) wave-length independence, (3) low electrical leakage, (4) independent of atmospheric temperature pressure, and humidity, (5) sealed against entrance of dirt and alpha contamination, (6) electrical insensitivity to dropping and mistreatment, (7) rugged construction, (8) easily charged and read by unskilled personnel, (9) low cost.

The Ryerson Pocket Meter is unique in that it meets all these specifications. It is designed for use in conjunction with the Victoreen "Minometer" or other quartz fiber electrometers having a capacity of about 2 cm. The Ryerson Pocket Meter has an electrical capacity of approximately 4 cm, a voltage of approximately 20 volts per 100 milliroentgens (0.10r) and a volume of approximately 6 cc, thus furnishing a sensitivity of 200 milliroentgens full scale. This range covers twice the presently accepted permissible daily dose of 100 milliroentgens.

To use the meter, it is inserted into the electrometer socket lightly making contact with the diaphragm contact. The cap is then charged to full voltage and observed for a few seconds to check leakage. If it leaks, it may be cleaned with mild soap and water using a toothbrush and dried with clean, dry compressed air or nitrogen. Reinserted, the diaphragm is first charged, light additional pressure allows placing a charge on central electrode. After exposure, the meter is reinserted, the cap charged and checked for leakage. If leakage is satisfactorily low, additional pressure obtains the reading. Excessive pressures will result in the generation of static charges on the diaphragm which may be removed by pressing on the diaphragm with the finger. Excessive pressures will eventually peen the contact button point and damage the meter.

Photographs and a diagram of the meter are included.

MDDC - 887 Isotopic Masses and Abundances, by H. A. Bethe and R. F. Christy, 6 p. July 21, 1943. (LADC-285).

A table contains the isotopic mass values which the authors consider most reliable. According to the given "probable errors," the masses up to neon are very much more accurately known than for the heavier elements. The lighter masses were calculated taking into account all of the more accurate data from mass spectrograph as well as disintegrations and attempting the best possible fit.

MDDC - 888 High Frequency Induction Heating, by L. Bromley, February 1, 1947, 44 pgs.

Equations are given to calculate at least approximately the heating in solid and hollow cylinders, slabs and spheres. Short and long cylinders are treated as well as short and long solenoids. The complicated mathematics used to derive the equations are omitted as they may be found in the original references.

Heating with a spark gap converter is covered. Equations are given which together with some experimental data enable the prediction of the efficiency, heating, or temperature to be expected as the charge or coil is changed. Units and conversion factors are mentioned briefly.

MDDC - 889 Micro Combustion Method for the Determination of Carbon, by W. E. Cady and C. N. Rice, 12 p., December 12, 1945. (LADC-286).

The sample was burned in oxygen at low pressure and the gaseous products of combustion were analyzed in a Prescott gas-analysis apparatus. The estimated limit of sensitivity for carbon is 20 ppm on a 50-mg sample.

Drawings of the following are included: a high vacuum carbon line, a multiple dumper, a platinum crucible, a quartz reaction vessel, and oxygen supply apparatus for a high vacuum carbon line, and a measuring burette.

MDDC - 890 Neutron Monitoring by Means of "Special Fine Grain Alpha Emulsion", by J. S. Cheka, 16 p., December 3, 1946.

Fine grain alpha emulsion film is used at Clinton Laboratories to monitor personnel for neutron exposure. Part of the film is behind a cadmium shield, which removes thermal neutrons, and part of it is exposed without a shield, intercepting both thermal and fast neutrons.

Calibrations were made to determine the sensitivity of the emulsion for both thermal and fast neutrons in terms of proton tracks observable under a microscope of 970x magnification. The ratio, 3.01×10^5 n_{th}/ observed track was noted for the $N^{14}(n,p)C^{14}$ reaction, and the ratio, 2.05×10^4 n_f/ observed track was noted for proton recoils. Evaluating expected track densities, based on N-atom density for n_{th} and H-atom density for n_f, the first process was found to be about 53% effective and the latter 46% effective in producing recognizable tracks of 3 grains or more in this emulsion.

Using tolerance values of 4700 $n_{th}/(cm^2 \text{ sec})$ and 266 $n_f/(cm^2 \text{ sec})$, two weeks' tolerance doses are indicated by 39 tracks/50 fields for n_{th}, and 33 tracks/50 fields for n_f. However, since different batches of the same type film were found to differ in sensitivity, each batch must be calibrated to establish the track density which indicates a tolerance dose.

MDDC - 891 The Dual Temperature Process for Isotopic Separation, Columbia University, 4 p., n.d., decl. 2/26/47.

The dual temperature process is essentially an engineering application of the principle that the equilibrium constant for isotopic exchange reactions varies with the temperature. The system uses two principal components, each of which can exist as a separate phase. These components contain a common constituent (i.e., two isotopic forms of an element) capable of taking part in a reversible exchange reaction. The desired constituent may concentrate in either phase, depending on the equilibrium constant for the reaction. The details of the method are given and recommendations for maximum efficiency are presented.

MDDC - 892 Spectrophotometric Studies of Plutonium in Aqueous Solution, by R. E. Connick, M. Kasha, W. H. McVey, and G. E. Sheline, 82 p., July 1946.

The absorption spectra of Pu(VI) and Pu(III) were measured in 0.5M nitric and hydrochloric acid solutions. Solutions of Pu(VI) were found to undergo slow reduction due to alpha-radiation products, and Pu(III) was found to be unstable in the presence of sulfate with respect to oxygen oxidation to Pu(IV). Lambert's Law and Beer's Law for Pu(VI) and Pu(III) solutions were tested. Instrument effects caused an apparent deviation from these laws for Pu(VI) while Pu(III) showed no deviation.

The absorption spectrum of Pu(IV) was calculated by correcting for Pu(III) and Pu(VI) in an equilibrium mixture resulting from the disproportionation of Pu(IV) in 0.5M hydrochloric acid. The absorption spectrum of Pu(V) was calculated from measurements on a solution of Pu(VI) during reduction by either sulfurous acid or hydroxylamine hydrochloride and at a time when the plutonium was in mainly the +5 oxidation state. Rate measurements made during the absorption curve determination permitted correction for the instantaneous amounts of Pu(III), Pu(IV), and Pu(VI) present.

By studying the effect of temperature on the absorption spectra, evidence for complex ion formation was obtained. The stabilization of complex ions at higher temperatures is interpreted on the basis of the entropy change involved.

The chloride complexing of Pu(VI) was demonstrated by measuring the effect of chloride concentration and temperature on the spectrum of Pu(VI).

A summary is given of the absorption spectra of the four oxidation states of plutonium in aqueous solution, and the absorption spectrum of the hydrolyzed form of Pu(IV) is also included. The structure of the spectra is discussed, and in particular, similarites between structure in the uranyl absorption spectrum and a region of the plutonyl absorption structrum are pointed out and interpreted as vibrational fine structure arising from a metal-oxygen vibration in these oxygenated ions.

The method of calculation used in spectrophotometric analysis of plutonium in its various oxidation states in aqueous solution is presented. All measurements were made by means of a Beckman Quartz Spectrophotometer Model DU, using either corex or quartz absorption cells. The wavelength region covered was about 3500 to 11000 A. In the Appendix a thermostated chamber for use with absorption cells in the Beckman Spectrophotometer is described. With this device absorption measurements were made at temperatures up to 70°C. Temperature effects of the spectrophotometer were analyzed by study of the neodymium ion spectrum.

MDDC - 893 Factors Involved in the Production of Atomic Power, by F. Daniels, 25 p., n.d., decl. 4/7/47.

This is a proposed talk covering the following topics: the fission process, principle of the pile, requirements of a pile, requirements of a power pile, types of engines, plans for the experimental power pile at Oak Ridge, hazards, special difficulties, chemical processing, atomic fuels, direct conversion of heat into work, heating, availability of uranium and thorium, economics, special fields of use, denaturing, and international control. (Most of this talk has been included in two published papers, Chemical and Engineering News Vol. 24 p. 1514, 1946 and Science Vol. 104 p. 2692, 1946).

MDDC - 894 Fast Amplifier Circuit Schematic, by W. C. Elmore, 1 p., n.d., decl. 4/22/47. (LADC - 386).

Circuit diagram

MDDC - 895 Model 300 Sweep (Drawing 574) by W. C. Elmore, 1 p., April 18, 1945. (LADC - 88).

Circuit diagram.

MDDC - 896 Model 501 Amplifier, by W. C. Elmore, 1 p., August 1, 1945. (LADC - 360).

Circuit diagram.

MDDC - 897 Use of Threshold Detectors for Fast Neutron Studies, by B. T. Feld, R. Scalettar, and L. Szilard, 1 p., n.d., decl. 12/26/46.

The whole document is reproduced here.

Light element (n,p) and (n,α) reactions can be used to compare, qualitatively, the energy distributions of the fast neutrons emitted by various neutron sources. Experiments are described in which a Ra-α-Be and Ra-α-B neutron source are compared by observing their relative activation of a number of light element reactions. A table summarizes the experimental results (See below). The thresholds for the reactions were calculated by using the best available values of the isotopic masses. The probability for penetration of the coulomb barrier by the product proton or alpha particle was calculated from the Gamow formula.

The relative values of the activities in the same column have no meaning, since the detectors were not intercalibrated. However, a comparison of the figures in the same row indicates that the Ra-α-Be source gives neutrons extending to a considerably higher energy than the Ra-α-B neutrons. This result is not surprising in view of the fact that the threshold for the Be(α,n) reaction is considerably lower than that of the B(α,n) reaction.

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Reaction	Half Life	Calculated Threshold (Mev)	Calculated Energy for 0.1 penetration (Mev)	Calculated Energy for 0.5 penetration (Mev)	Activity/Activity $S^{32}(n,p)P^{32}$ Ra-α-Be	Ra-α-B
$S^{32}(n,p)P^{32}$	14.3d	.93	2.9	4.0	1.000	1.000
$S^{31}(n,p)Si^{31}$	170m	1.02	2.9	3.9	.63	.51
$Al^{27}(n,p)Mg^{27}$	10.2m	1.95	3.6	4.6	.29	.058
$Si^{28}(n,p)Al^{28}$	2.4m	2.69	4.5	5.5	.95	$\leq$.017
$P^{31}(n,\alpha)Al^{28}$	2.4m	.90	6.6	8.3	.24	$<$ .004
$Al^{27}(n,\alpha)Na^{24}$	14.8h	2.39	7.5	9.1	.079	$<$ .003

MDDC - 898 Fluorocarbons to June 30, 1943, by R. B. Fowler and W. B. Burford, III, 179 p., n.d., decl. Jan. 31, 1947.

A new and general method for the production of fluorine-substituted hydrocarbons was discovered and developed. The method consists in the reacting of vaporized hydrocarbons with solid CoF_3 at temperatures from 150-400°C., resulting in completely fluorine-substituted hydrocarbons, CoF_2 and HF. The CoF_2 is reconverted to CoF_3 by means of elementary fluorined. Many new fluorinated organic compounds have been discovered, among them C_7F_{16}, perfluoro-n-heptane; C_8F_{16}, perfluoro-dimethyl-cyclohexane; $C_{10}F_{22}$, perfluoro-cetane; C_7F_{14}, perfluoro-ethyl-cyclopentane; and C_7F_{14}, perfluoro-dimethyl-cyclopentant. Development of fluorine cells, ranging from small 15 ampere laboratory models to 800 ampere semi-commercial size cells is described. Various reactors, including pilot plant scale models are described, and operating conditions were determined. Physical data, including viscosity, vapor pressure, surface tension and critical pressure and temperature were determined on several of the new fluorinated compounds.

MDDC 899 Four-Fold Hand Counter, by W. Q. Gulley, D. R. Luster, and G. S. Pawlicki, 14 p., November 1, 1944. (CP-2188).

The four-fold hand counter is designed for the rapid determination of beta and gamma contamination of the hands. Its main advantages over previous instruments are: (1) it checks the contamination of both sides of both hands simultaneously, (2) it obtains improved geometry by the use of two G-M counters for each side of each hand, (3) its operation is simple and automatic so that no operator is required, and (4) it reduces the chance of human error by means of automatic timing.

A general physical description, a description of circuit operation, installation and service details, parts list, and diagrams of the instrument are included.

MDDC - 900 30 KV Power Supply, by W. A. Hane, 1 p., n.d., decl. 4/23/47. (LADC - 380).

Circuit diagram.

MDDC - 901 The Determination of U_3O_8 in Canadian Ores by Means of the "Ten Per Cent" Reductor, by R. J. Heaney, 6 p., May 27, 1946. (A-2917).

The efficiency of the ten per cent reductor in overcoming the interference of nickel in the determination of U_3O_8 volumetrically is verified with a group of synthetic mixtures. The deleterious effect of copper in ore samples is noted, and the various effects of the presence of copper are investigated. The satisfactory determination of uranium in nickel bearing ores, provided that copper and reducible elements other than uranium are removed, is shown.

MDDC - 902 Geiger Counter Radiation Meter, by W. H. Hinch, 6 p., December 20, 1943. (CP-1161 [A-1644]).

The Geiger counter meter considered may vary in kind and size depending on the type of radiation to be measured and the sensitivity desired. The range of intensities that it is possible to measure with the meter varies from individual pulses to approximately .1r/8 hr. Preliminary investigations indicated that it would be possible to measure higher intensities.

A circuit diagram is shown and described in detail and directions given for the adjustment and operation of the meter, its calibration, and modification, if used as a direct finder.

MDDC - 903 Determination of Rare Earth Elements in Uranium Compounds, by R. C. Hirt, 8 p., June 24, 1944.

The separation of the "rare earth" elements from uranium and its compounds may be obtained by means of an ether extraction, precipitation as fluorides, and purification by way of the hydroxides. The final determination is carried out spectrographically, using a Jarrell-Ash Wadsworth Spectrograph and an A. R. L.-Dietert Multisource. Dysprosium, gadolinium, samarium, neodymium, praseodymium, lanthanum, and cerium were investigated, and their limits of sensitivity and their recoveries from U_3O_8 determined. The method may be applied to other "rare earth" elements as well.

MDDC - 904 Reactions between Plutonium Ions in a Perchloric Acid Solutions Rates, Mechanisms and Equilibria, by M. Kasha, 74 p., August 30, 1946.

The reaction mechanism for the disproportionation of Pu(IV) to Pu(VI) and Pu(III) was tested in an experiment in which a mixture of Pu(IV) and Pu(VI) was diluted to yield a solution having a concentration of 1.73×10^{-3} M in plutonium and 0.481 M in perchloric acid (no added salt). The data best fit a rate law in which the rate of disproportionation of Pu(IV) is proportional to the square of the Pu(IV) concentration for the forward reaction. The rate constant for this rate law is

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3.2 liters mole^{-1} hour $^{-1}$ at 25°C. The equilibria between Pu(III), Pu(IV), Pu(V) and Pu(VI) have been studied as a function of acidity, in perchloric acid solutions at an ionic strength of 1, at 25°C. The reactions were carried out generally by mixing solutions of Pu(III) and Pu(VI) at the desired acidity, salt concentration and temperature. At low acidities (0.05 M) this procedure permitted study of equilibria involving Pu(V) without the formation of colloidal Pu(IV), since Pu(IV) occurred in but relatively small amounts under such conditions. The equilibrium constant, $K_1 = \frac{(Pu(III))\ Pu(VI))}{(Pu(IV))\ (Pu(V))}$, was found to be 7.4 and 10.7 for the 0.0520 M and 0.1019 M perchloric acid experiments (ionic strength = 1) at 25°C. For a precise definition of an equilibrium involving Pu(V), an equilibrium constant not involving the concentration of Pu(IV) (in which there were large analytical uncertainties due to its small relative concentration) was calculated, $K_5 = \frac{(Pu(III)\ (Pu(VI))^2}{(Pu(V))^3}$, giving values of 2.82 and 31.3 for the 0.0520 M and 0.1019 M perchloric acid experiments (ionic strength = 1) at 25°C, indicating an inverse 3.6 power dependence on hydrogen ion concentration. The equilibrium between Pu(III), Pu(IV) and Pu(VI) is defined by the constant $K = \frac{(Pu(III))^2\ (Pu(VI))}{(Pu(IV))^3}$, for which values of 252, 40.2, 0.195, and 0.0405 were obtained for experiments in 0.0520, 0.1019, 0.516 and 0.994 M perchloric acid respectively, all at an ionic strength of 1 and 25°C. These data best fit a third power dependence on hydrogen ion concentration for the Pu(III)-Pu(IV) equilibrium constant. Since a fourth power dependence is expected on the basis of the presently accepted formulas for the plutonium ions, and since hydrolysis does not explain the dependence found, further work is required for an explanation of these results.

A description is given of the criteria to be observed for the stabilization of maximum amounts of Pu(V) in equilibrium with other plutonium ions in aqueous solution at 25°C. These include (a) conducting the experiments at lowest permissible acidity, (b) having an average oxidation number of plutonium at slightly greater than +5, (c) starting the experiments by mixing solutions of Pu(III) and Pu(VI) so that the formation of colloidal Pu(IV) is forestalled by preventing the occurrence of large concentrations of Pu(IV) at low acidities. Calculations indicate that in 1 M perchloric acid Pu(V) can exist to the extent of 0.5%, while in 0.01 M perchloric acid (at an ionic strength of 1), over 60% of the plutonium will be in the form of stable Pu(V). Experimental application of these criteria and calculations lead to the preparation of solutions containing large amounts of Pu(V) in stable equilibrium with the other oxidation states of plutonium in aqueous solution at 25°C.

The rate of reduction of plutonium in aqueous solution due to products of the plutonium alpha-radiation was calculated from the change in average oxidation number of the plutonium in long term experiments. The mean rate of diminution in the average oxidation number of plutonium was found to be 0.0118 per day at 25°C, and independent of acidity over a range of from 0.1019 M to 1.992 M perchloric acid. The solubility product of Pu(OH)4 was calculated from data on plutonium equilibrium experiments in 0.05 M acid at 25°C, in which slow formation of colloidal Pu(IV) occurred during a 500 hour interval. Assuming that the system represents equilibrium between Pu^{+4}, OH^-, and Pu(OH)4, a value of 7.1×10^{-56} is obtained for the solubility product of Pu(IV) hydroxide.

Absorption spectra of Pu(III) and Pu(VI) in perchloric acid (at an ionic strength of 1) at 25°C are given, and a precision absorption cell assembly is described.

MDDC - 905 A General Method for Determining Coincidence Corrections of Counting Instruments, by T. P. Kohman, 24 p., June 13, 1945. (CP-3275).

The method described for determining and applying coincidence corrections in counters is an extension of the general method of paired sources. Several pairs of radioactive sources are used, and for each pair, counts are taken with the instrument on the sources separately and together. A general relationship between the recorded counting rate (R) and the "true" rate (N) is assumed, being the first few terms of an infinite power series:

$$N = R + \tau R^2 + \nu R^3 + \phi R^4 + \ldots\ldots,$$

Where τ is the resolving time of the counter and $\nu, \phi, \ldots\ldots$ are independent parameters. By a least-squares method, the values of the parameters for the instrument in question are determined which most adequately correlate the experimental data. Subsequent measurements made with the instrument can then be corrected by means of this equation.

A few examples of the use of this method are presented. They indicate that the method is a satisfactory solution of the problem and should be of considerable value.

MDDC - 906 Chemistry of Plutonium V - 1. Potential of the Plutonium (V) (VI) Couple. Ionic Species of Plutonium (V) in Acidic Solutions, by K. A. Kraus and G. E. Moore, 17 p., Feb. 27, 1947.

Through potentiometric titrations the potential of the Pu(V)/(VI) couple in chloride and perchlorate solutions was found to be Ca. -0.93 v near pH 3 at 25°C. Since this value is in reasonably good agreement with a potential previously determined for an 0.5 M HCl solutions, and since the hydrolytic behavior of Pu(VI) is sufficiently well know, it can be concluded that the Pu(V) species in acidic solutions is PuO_2^+ with an undetermined number of water molecules of hydration. This conclusion was confirmed through pH measurements during reduction of Pu(VI) to Pu(V) near pH 3.

A bibliography is included.

MDDC - 907 Biological Action of Gamma and X-Rays. I. Exposure of Mice to Daily Doses of Gamma Radiation at Two Rates: 5.5 r/Hr and 0.11 r/8 Hr, by E. Lorenz, A. Eschenbrenner, M. Derringer, and W. E. Heston, 34 p., December 22, 1944. (CH-2576) (See also Journal of the National Cancer Institute Vol. 6 p. 349-353, 1946 and Cancer Research Vol. 6 p. 485, 1948).

Haematology: Female LAF_1 mice were exposed to daily doses of 5.5 r in one hour (I_1) and 5.5 r in one hour, plus 0.11 r in 8 hours. Biweekly blood counts were taken on these animals. They came to autopsy after having received total doses ranging from 600 to 1600 r. The blood picture of these animals is comparable to that of controls of the same age with the exception that the neutrophil count was higher than normal for most of the experimental animals. This increase in neutrophils was probably due to a low grade pneumonia and not due to the irradiation.

Pathology: Radiation effects were observed only in lymph nodes, spleen and ovaries while all other organs were within normal limits histologically.

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Breeding: Breeding experiments showed that a single dose of x-rays of 300 r given in 7 1/2 minutes, will result in sterility after one litter of reduced size was born. Breeding experiments in which 330 and 440 r were given at the rate of 5.5 r per one hour per day gave litters of normal size and the mice remained fertile up to about 1 year of age, which is approximately the breeding end point of normal mice. Mice exposed to 770 r at the rate of 5.5 r per 1 hour per day gave one litter of greatly reduced size and were sterile thereafter. This finding is in agreement with other experiments, in which mice were exposed at the rate of 4.4 r per day, 8.8 r per day and 8.8 r per 8 hours per day. These animals when exposed to total doses of 770 and 880 r also became permanently sterile after one litter of reduced size was born. These breeding data are in agreement with the pathological observation of the I_1 and D_7 mice which showed that at a dose of approximately 900 r large follicles begin to disappear.

It can be concluded therefore that an exposure of mice to 5.5 r per hour per day up to total doses of approximately 1600 r produces radiation effects on the ovaries similar to and not more pronounced than those observed when similar doses are given at the rates of 4.4 r per day, 8.8 r per day and 8.8 r per 8 hours per day. The discrepancy between a single sterilization dose of 300 r and a dose of approximately 900 r given daily at the above rate seems to indicate that a certain amount of recovery of the ovary is possible when doses are subdivided. Whether the subdivision of the dose or the rate of administration of the dose is more important in producing sterility has to be decided by further experiments.

MDDC - 908 Model L.A. - 100 C. R. Oscilloscope, by Los Alamos Laboratory, 1 p., n.d., decl. 1/8/47. (LADC - 81).

Circuit diagram.

MDDC - 909 Engineering and Economic Aspects of Power from Atomic Energy, by J. H. Lum, 20 p., n.d., decl. April 1947. (See also Chemical Engineering Vol. 54 p 122-125, October, 1947)

The production of power from atomic energy involves engineering problems that are difficult but solvable. The economics are encouraging, particularly in parts of the world where power is much more expensive than in the United States. First applications will probable come where cost considerations are not important, such as in military uses.

MDDC - 910 A Comparison of Analytical Methods for the Determination of Uranium, by D. A. MacInnes and L. G. Longsworth, 6 p., November 24, 1942. (A-378).

The uranium content of a preparation of hydrated UO_3 was determined by three independent procedures: prolonged successive ignitions in air at 700°, 820°, and 930° to lower oxides of the approximate composition U_3O_8, further reduction of the same samples to UO_2 by dry hydrogen at 900°, and titration with ceric sulfate of the $U(SO_4)_2$ obtained by passing a sulfuric acid solution of the UO_3 through a Jones reductor and aerating the somewhat over-reduced solution. The results of these three methods showed an extreme difference of 0.08%.

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A modified titration procedure was adapted to 5 mg of UO_3, in which the over-reduced uranium sulfate solution was aerated to the uranous stage and oxidized to the uranyl condition by excess permanganate, the excess being determined by differential potentiometric titration with ferrous sulfate. The results generally agreed closely but failed to give the true quantity of uranium.

Extensive application of the differential titration method to over-reduced solutions failed to locate the precise end-point of the U^{+3} - U^{+4} change. The difficulty is believed to reside with the excessively strong reducing power of the U^{+3} ion.

The reduction of uranyl solutions with silver has been generally assumed to proceed quantitatively to the uranous stage. However, some over-reduction appears to be possible.

MDDC-911 The Measurement and Interpretation of pH and Conductance Values of Aqueous Solutions of Uranyl Salts, by D. A. MacInnes and L. G. Longsworth, 13 p., November 24. 1942.

pH values of aqueous solutions of UO_2Cl_2, $UO_2(NO_3)_2$, $UO_2(C_2H_3O_2)_2$ and UO_2SO_4, and pH and conductance measurements on solutions of UO_3 in aqueous HCl are reported. Approximate values for the solubility of UO_3 in aqueous HCl are also included. Although only slightly soluble in water UO_3 dissolves in aqueous HCl to the extent of about 1 mole of base to 1 mole of acid.

Both electrometric and conductometric titrations of UO_3 with HCl yield, however, a sharp endpoint only at 2 moles of acid per mole of base, corresponding to the divalent uranyl ion UO_2^{++}.

The additional solubility of UO_3 in aqueous UO_2Cl_2 may be due to either of the following reactions.

$$UO_2^{++} + UO_3 + H_2O = 2UO_2OH^+$$

$$UO_2^{++} + UO_3 = UO_3.UO_2^{++}$$

Conductance and transference measurements cannot distinguish between these two mechanisms. pH measurements appear to favor the second process.

MDDC-912 Effects of Radiation Exposure on the Cells of the Peripheral Blood, by E. K. Marks, 6 p., March 1947.

A reduction in the erythrocyte values may be expected following acute and chronic total body irradiation. The anemia following chronic total body irradiation may be normocytic, hyperchromic, or macrocytic depending upon the size of dose and the sensitivity of the subject. The toal number of reticulated erythrocytes is reduced following radiation exposure, but no changes have been found in the morphological character of the reticulum.

Along with the reduction of platelet values after irradiation, giant thrombocytes are frequently found, occasionally larger than normocytes. The hyalomere is extremely abundant and the granules in the chromomere are usually prominent and large.

The most sensitive cellular constituent of the peripheral blood appears to be the lymphocyte, and the reduction in its values closely parallels that of the total number of leukocytes. With increasing amounts of radiation exposure, the number of lymphocytes with abnormal morphological characteristics increases.

MDDC-913 Apparatus for Regulating Fluorine Flow, by W. T. Miller, 1 p., n.d., decl. 4/29/47.

A schematic diagram of an apparatus for regulating fluorine flow.

MDDC-914 Electronic Circuits VI, by M. Sands, et al., 3 p., December 1944, decl. 4/22/47. (LADC-359).

A circuit diagram is presented of a scaler, Model 411, scale of 64 with an rf power supply, which can be varied from 600 to 1500 volts for the Geiger Mueller tubes. The scaling stages are of the Higinbotham type. A mechanical mercury register is shown. The report also contains a parts list for the components of each scaling stage.

MDDC-915 Test Unit Power Supply, by M. Sands, 1 p., November 1, 1944, decl. 4/22/47. (LADC-384)

The circuit diagram for a power supply for a test unit is shown. This supply furnishes 300 volts positive at 100 milliamperes, valve tube electronically regulated, and 150 volts negative at 25 milliamperes VR tube regulated. There is also available for the test unit, a filament voltage of 6.3 volts.

MDDC-916 Blood Platelet Counting, by E. Skirmont, 1 p., March 1947.

A modified method for blood platelet counting is described in respect to reagents to be used, technic, directions for making the count, and method of calculation.

MDDC-917 Time for Emission of Fission Neutrons, by T. Snyder, R. W. Williams, Jan. 21, 1944, 39 p.

The Baker experiment to detect times of delay of the emission of fission neutrons greater than 10^{-9} sec has been performed by observing the change in fission neutron counting rate when fission fragments are allowed to fly away from a neutron counter as compared to the counting rate when the fragments are kept in its vicinity. The fission neutrons were detected by observing proton recoils in a thick-paraffin lined proportional counter. The percent of neutrons delayed by a time of the order of 10^{-8} sec was found to be 3.4 ± 1.9 per cent.

MDDC-918 Rhodium Radioisotopes Induced in Deuteron-Bombarded Ru, by W. H. Sullivan, 3 p., November 9, 1946.

A letter in which the essential information concerns the radioactivity of Rh, taken from report CC-1493, is presented.

During a series of experimental investigations to determine what artificial radioactivity was induced in deuteron-bombarded Ru, it was observed that four radioisotopes, with half-life values of 21 hours, ~36 hours, 59 days, and ~200 days could be identified chemically as Rh. Methods of procedure are given which led to the identification of Rh^{100}, Rh^{105}, Rh^{101}, Rh^{102}.

MDDC-919 Dynamics of a Mass of Hot Gas Rising in Air, by G. I. Taylor, 19 p., March 16, 1945.

The theory developed here may be used to treat the dynamics of a ball of fire produced in a large explosion. At first this ball is a sphere of hot gases which starts to rise through the air. Its dynamics are considered in Part II. Its behavior is very similar to the rise of an air bubble through water. It soon flattens out like the top of a mushroom, its top remaining spherical while its bottom becomes flat. As it rises the stream of cold air flowing over its surfaces eats away the hot gases in turbulent convection. Most of the material eaten away comes from the lower surface. As the ball rises it maintains its shape but becomes smaller due to the loss of material. Finally after a rise of

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3.7 times its original radius, the ball is completely dissolved in turbulence. The figure 3.7 depends on two considerations. First, it is known experimentally for air bubbles in water that the drag coefficient, C_D, is approximately 0.7. Secondly, the amount of air which gets sucked into the turbulent stream can be estimated from experimental observations of the motion of air produced above a long straight hot wire (thus the constant is taken as 0.2). The fate of the turbulent column of air is treated in Part I. The original ball of fire is considered to be comparable to an instantaneous point source of heat. Knowing the total amount of heat input, and the rate of rise of potential temperature with height in the atmosphere (taken to be 5° per 1000 meters) the dynamics of the turbulent column can be estimated. This theory predicts in agreement with observations that the column should rise to a maximum height and then mushroom out. The height should vary as the energy of the explosion to the one-fourth power and inversely as the one-fourth power of the rate of rise of potential temperature in the air. In the case of the Port Chicago explosion involving 1600 tons of H. E., this theory predicts that the maximum height should be 11,000 feet. Observations would indicate that this height was actually between 8,000 and 12,000 feet. The theory is admittedly rough. An attempt is made to justify it by using the same sort of development for the case of turbulence produced by a hot wire in air and comparing it with the results of Schmidt's) more accurate theory. Schmidt's theory is presented in the Appendix.

MDDC-920 Battery Operated Field Pulser, by E. W. Titterton, 1 p., June 7, 1945, decl. 4/10/47. (LADC-368).

A circuit diagram is reported for a battery operated field pulser. An 884 thyratron tube is used for generating the pulses. There is provision for either a single pulse or for repetitive pulses.

MDDC-921 Calibrated Sweep Generator, by E. W. Titterton, 1 p., September 6, 1944 decl. 4/28/47. (LADC-350)

A circuit diagram for a calibrated sweep generator is shown. The generator consists of the following components: a pulse generator, an inverter, cathode follower, gate multi-vibrator, inverter clamp, oscillator, and sweep generator. The circuit is self-sufficient except for an external 300 volts supply. The filament transformer is included.

MDDC-922 Duo Sweep and Marker Generator with Calibrator, by E. W. Titterton, 1 p., n.d., decl. 4/10/47. (LADC-377).

This report consists of a circuit diagram for a duo-sweep and marker generator with calibrator. The power supply for the circuit is not included. The sweep and marker generator with calibrator may be used in connection with an oscilloscope.

MDDC-923 Fast Sweep and Scope, by E. W. Litterton, 1 p., n.d., decl. 4/9/47. (LADC - 366).

A circuit diagram has been reported for a fast-sweep and power supply for an oscilloscope.

MDDC-924 1500 Microsecond Delay Unit, by E. W. Titterton, 1 p., December 18, 1945, decl. April 16, 1947. (LADC-375).

A circuit diagram is given for a 1500 microsecond delay unit. The diagram shows an electronically regulated power supply and 300 volts which are used for the β plus of the delay circuit. A switch is included which gives a variable delay time.

MDDC-925 Four Channel Line Driver, by E. W. Titterton, 1 p., n.d., decl. 4/9/47. (LADC-373).

A circuit diagram for a four channel line driver is reported. Only one channel is shown since numbers two and three are identical to number one. Channel number four is also shown.

MDDC-926 High Voltage C. R. O., by E. W. Titterton, et al., 1 p., June 20, 1944, decl. 4/22/47. (LADC-356).

A circuit diagram is shown for a high voltage power supply to be used in connection with an oscilloscope. Connections are shown which are to be used with the 5CP5 oscilloscope, and connections are also shown which are to be used with the 5JP5 oscilloscope. The power supply gives approximately 4 kv positive and minus 2.5 kv.

MDDC-927 Model Six Sweep, by E. W. Titterton, 1 p., n.d., decl. 4/28/47. (LADC-369).

A circuit diagram for the Model 6 sweep circuit is shown. This unit is complete, having its own power supply. It has either a positive sweep output or a negative sweep output with the repetition frequency variable. It can also be used for a single sweep test.

MDDC-928 Multiple Scope and Power Supply, by E. W. Titterton, 1 p., January 20, 1945, decl. 4/22/47. (LADC-357).

A circuit diagram for a multiple scope and power supply is given. The diagram shows the connection to be used with the 5CP5 cathode ray tube.

MDDC-929 Regulated Power Supply + 450V, + 300V, and -150V for Fast Sweep Chassis, by E. W. Titterton, 1 p., January 1, 1945, decl. 4/22/47. (LADC-383).

A circuit diagram is reported showing a regulated power supply, giving various combinations of 300 volts, 450 volts, or 150 volts. There are two regulated supplies, one for a 300 volt positive voltage and one for the minus 150 volt. Both regulators use the valve type electronic regulation. The 300 volt supply would be rated at approximately 200 milliamperes, and the minus 150 volt supply would be rated at approximately 90 milliamperes.

MDDC-930 Saw Tooth Generator and Discriminators, by E. W. Titterton, 1 p., November 20, 1945, decl. 4/7/47. (LADC-372).

A circuit diagram has been reported for a saw tooth pulse generator and a discriminator.

MDDC-931 Three Channel Mixer. by E. W. Titterton, 1 p., November 24, 1944, decl. 4/15/47. (LADC-363).

A circuit diagram for a three channel mixer is set up. The system is complete, having its own electronically regulated power supply. The three channels use 6V6 tubes for mixing purposes. One channel is for a marker input, while the other two channels are for X-ray inputs.

MDDC-932 Camera Synchronizer, by G. E. Whitham, 1 p., November 1944 (LADC-388).

Circuit diagram for a camera synchronizer designed to handle pulses of micro second duration.

MDDC-933 Theory of the Synchro-Cylotron, by D. Bohm, L. L. Foldy, 32 p., n.d., decl. 5/12/47. (See also Physical Review, Vol. 72, p. 649-661, Oct. 15, 1947)

In the synchro-cyclotron (or frequency- modulated cyclotron) the higher energies available are obtained at the expense of a decrease in the ion current compared with that available from the conventional cyclotron. This decrease results from the fact that during only a small fraction of the frequency-modulation cycle is it possible for ions to be captured into phase stable orbits that do not return to the center during the first phase oscillations. By solving the phase equation, it is possible to obtain a general expression for this fraction, which is defined as the capture efficiency. At a constant dee-voltage and varying rate of frequency modulation the capture efficiency has a maximum at an equilibrium phase angle of 30° (corresponding to an energy gain per turn equal to half the maximum available). For larger equilibrium phase angles the effeciency decreases as a result of the smaller range of phase stability, while for smaller phase angles it decreases as a result of return of particles to the center. The maximum effeciency is proportional to the square root of the dee voltage or alternatively to the square root of the rate of frequency modulation, and depends on the charge and mass of the ions only through the ratio of charge to mass. Comparisons of the theoretical expectations with available experimental data show satisfactory agreement. Capture efficiencies for present designs of synchro-cyclotrons are of the order of 0.1 to 2 percent.

MDDC-934 The Nature and Production of Radioactivity, by W. E. Cohn, March 6, 1947, 56 p.

The manuscript is a chapter of a book entitled "Advances in Medical Physics", edited by J. H. Lawrence and J. G. Hamilton, published by Academic Press.

The following topics are stressed: the nature of radioactivity, nuclear reactions, chemical factors in radioisotope production, and availability of radioisotopes.

MDDC-935 Studies of Capture Gamma Rays, by S. M. Dancoff and H. Kubitschek, 50 p., April 1946. (CP-3496).

A neutron beam from the heavy water pile was allowed to fall on various targets and the gamma radiation resulting from neutron capture was studied. The maximum energy of such radiation is determined for 17 targets. This method measures the binding energy of the neutron.

The "yield" of gamma rays from neutron capture is defined as the response of a GM tube in a certain specified geometry per neutron captured in the target. This yield, which would be the same for absorbers which gave off identical gamma spectra, was found to exhibit considerable uniformity for over 30 materials investigated. In this experiment, which is preliminary as far as yield measurement is concerned, only thermal neutron beams were used.

MDDC-936 Ocular Lesions Following the Atomic Bombing of Hiroshima and Nagasaki, by J. J. Flick, 43 p., n.d., decl. 5/13/47.

The transient nature of the condition and the chronologically short period over which the studies were made tend to limit any definite conclusions as to pathogenesis of these lesions. As a result of repeated examinations of the same individuals and of repeated examinations of the same lesions it seemed likely that the exudative lesions represented the milder involvement. This is born out statistically. Those individuals showing both hemorrhage and exudation were on the average closer to the site of the explosion and had lower white cell counts than did those with either hemorrhage or exudation alone. The witnessing of a transition from the fluffy exudate to the "Roth" type hemorrhage and pre-retinal hemorrhage was rather impressive. The author concludes that local areas of the retina could become swollen by transudation of serum through the walls of hyperpermeable capillaries in the presence of anemia, oligocythemia, and consequent lowered oxygen tension in the blood. If this process were to become so intense as to cause tissue breakdown in the lesion itself as a result of stasis and anoxemia the extravasation of whole blood elements could occur superimposing itself on the original lesion, coming to surround it as "the hemorrhage with the white center".

The location of these lesions near large vessels was explained by the increased intravascular pressure in vessels of larger size. Once engendered by complete vascular rhexis the bleeding was not halted or modified by the clotting mechanism since practically none existed. The tendency of the preretinal blood to settle in layers was no different than its behavior in the sedimentation test tube. The spotty localization of the retinal lesions was probably based on slight local anatomico-physiological differences in the circulation in the fine branches of the terminal retinal vessels.

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The oscular lesions here described are directly related to the deficiency in blood elements and in no way directly related to the action of radiant energy on the eye. The lesions were observed to disappear in those individuals recovering from hematopoietic depression with no residual damage to the eye. This healing occurred in all cases that survived the irradiation and no permanent residual damage of permanent nature resulted from the retinal lesions. Radiation damage to the lens could not be determined at this early date.

Included are clinical studies of 46 patients injured by the atomic bombs and a survey of the published literature.

MDDC-937 Health Physics and Its Control of Radiation Exposures at Clinton Laboratories, by K. Z. Morgan, 35 p., n.d., decl. 5/6/47 (See also Chemical and Engineering News Vol. 25 p. 3794-3798, December 22, 1947)

People working on the Plutonium Projects have been subjected to exposures of radiation equivalent to millions of times that from all the radium in the world. Yet because of the elaborate precautionary measures taken by the Health Physics departments, no person has averaged a radiation exposure in excess of one tenth of the yearly tolerance dose. Recent measurements indicate radiation damage at low levels of radiation. The Plutonium Projects at the beginning of their operation set the maximum permissible level of radiation exposure at 100 mrem/day for all types of radiation and the Health Physics departments have maintained an actual tolerance level of about 10 mrem/day. The tolerance levels of exposure to the body, clothing, hoods, etc. are given in a table. The general tolerance concentration for β or γ emitters is given as 10^{-7} μc/cc of air or 5×10^{-4} μc/cc of water. The corresponding values for α emitters are 3×10^{-11} μc/cc of air or 10^{-5} μc/cc of water. Special films are worn by each person in the restricted area. These are used as personnel monitoring meters to determine the exposure each person has received from α, β, γ, thermal neutrons and fast neutrons. Pocket meters are worn also to assist in obtaining a rapid indication of the radiation exposures. Many varieties of survey instruments are used by the Health Physics surveyors to maintain the working areas in and about the laboratories safe from excessive radiation exposure. A chart is given which lists the survey instruments and the tolerance levels that each can measure.

MDDC-938 On the Existence of a Calcium Isotope with an 8.5 Day Period, by R. Overstreet and L. Jacobson, 3 p., November 1946. (BC-44) (See also Physical Review Vol. 72 p. 349, August 15, 1947)

An attempt to produce Ca^{41} was made by (a) bombardment of $CaCl_2$ with 20 Mev deuterons to the extent of 40 micro-ampere-hours (b) bombardment of KCl with 20 Mev deuterons to the extent of 135 micro-ampere-hours (c) bombardment of argon gas (2.5 liters) with 40 Mev alpha particles to the extent of 20 micro-ampere-hours.

On the basis of these experiments it was concluded that if a Ca^{41} isotope exists that emits beta or gamma rays or energetic conversion electrons, its half life must be considerably less than one day or longer than one year.

MDDC-939 Studies of the Delayed Neutrons. I. The Decay Curve and the Intensity of the Delayed Neutrons, by A. H. Snell, et al., 11 p., n.d., decl. 5/9/47. (See also Physical Review, Vol. 72, p. 541-544, October 1, 1947).

The delayed neutrons resulting from slow neutron fission of uranium were found to decay as a combination of exponentials with half-lives of 0.4, 1.8, 4.4, 23 and 56 seconds and respective initial relative intensities when activated to saturation of 0.4, 0.5, 1.1, 1.0 and 0.14. Under equilibrium conditions the delayed neutrons are $1.0 \pm 0.2\%$ as abundant as the instantaneous fission neutrons.

MDDC-940 Studies of the Delayed Neutrons II. Chemical Isolation of the 56 Second and the 23 Second Activities by A. H. Snell,et al, n.d., decl. 3/9/47. 16 p. (See also Physical Review, Vol. 72, p. 545-549, Oct. 1, 1947).

The 23 second delayed neutron activity was found to follow the chemistry of iodine, and the 56 second delayed neutron activity was found to follow the chemistry of bromine. Comparison with known beta emitters of like half-lives suggests that the neutron-emitting nuclei may be Xe^{137} and Kr^{87}.

MDDC-941 Determination of Small Amounts of Beryllium by Fluorescence Measurement, by A. L. Underwood, W. F. Neuman, A. B. Carlson, Feb. 27, 1947, 17 p.

The fluorescence of alkaline beryllium solutions with quinizarin has been studied in detail. pH, dye concentration and many common ions have been shown to influence the fluorescence of the complex. From these studies a procedure was developed for the determination of beryllium in amounts of 1-10 micrograms. There is reason to believe that the method can be extended to determine even smaller amounts of beryllium.

MDDC-942 Eight Inch Vacuum Pump, by H. S. Bridge, 6 p., May 9, 1947. (LADC-345).

Engineering drawing of component parts and complete assembly of an eight inch vacuum diffusion pump.

MDDC-943 Four Inch Oil Diffusion Pump, by H. S. Bridge, 8 p., n.d., decl. 5/9/47. (LADC-342).

Engineering drawings of the component parts and complete assembly of a four inch oil diffusion pump.

MDDC-944 Preparation and Properties of Fluorocarbon Oils, Waxes, and Resins, by G. H. Cady, 20 p., January 9, 1943.

The procedure for the fluorination of high molecular weight hydrocarbons is described and the apparatus shown in diagram. The yields of fluorocarbon oils and waxes are given in tables.

MDDC-945 Mass Ratios and Energy Release in the Fission of U^{235} and Pu^{239} by Thermal Neutrons, by M. Deutsch, January 31, 1946. 30 p.

The pairs of simultaneous fission fragments were observed in a double ionization chamber using electron collection. The most probable energy of the heavy fragment is for U^{235}: 60 Mev; Pu^{239}: 65 Mev. The most probable energy of the light fragments is in the same order, 94, and 93 Mev. The overlap of the two groups is about equal in both cases and may well be entirely instrumental. The most probable total-kinetic-energy release is, for the two substances in the above order: 153 Mev, and 156 Mev. The most probable mass after emission of the prompt neutrons for the heavy fragment in both cases seems to be about 140 mass units. The most probable mass of the light fragment for U^{235} is about 93; for Pu^{239}, 98. The highest fission yield for a single mass number should be about 5 1/2% in both cases. The energy release for splitting in a given ratio seems to be nearly the same for both substances.

Numerous graphs are included.

MDDC-946 Energy Distribution of the Fragments Resulting from the Fission of U^{235} and Th^{232} by Slow and by Fast Neutrons, by J. L. Fowler, L. Rosen, 20 p. (See also Physical Review, Vol. 72, p. 926-930, Nov. 15, 1947)

The distribution of energies of the fragments from 235 fission produced by slow and by fast neutrons were compared. Energy was determined by using a ten-channel amplitude discriminator to analyze pulses from a Frisch-grid ionization chamber. No difference was found outside the experimental error. The energy distribution of the fragments from thorium fission was also determined. The high-energy tails of the distributions were especially investigated for the purpose of detecting the occurrence of triple fission. This indicated a negative result. A possible correlation between the most probable mode of disintegration of the nucleus and its atomic number suggest itself.

A number of graphs are included.

MDDC-947 Cosmic-Ray Induced Fission, by D. Froman, L. Rosen, B. Rossi, n.d., decl. 5/9/47.

This is an abstract and it is given here in its entirety.

Eastman special fission plates in contact with 1 mb/cm^2 metallic foils of U-235 (bare and surrounded with 2" of paraffin), U-238, Pb and Bi were exposed to cosmic-ray neutrons during five-hour flights at 25,000 and 30,000 ft. The plates are insensitive to alpha and other radiations but record all fission-fragment tracks. Examination of the plates is incomplete. However, the following results are clear already. The flux of neutrons of energy above the fission threshold of U-238 is small since no tracks have been found in 0.4 cm^2 of plate examined to date. Cursory examination has given no indication of fission in Pb or Bi. The fission rates of the bare and

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paraffin-covered U^{235} foils are about those which would result on exposure of the bare foils to thermal neutron fluxes of 20 and 130 neutrons/cm^2 min respectively, calculated on the basis that the thermal fission cross section for natural uranium is 3 barns. The precision of these values is low but will be improved on further examination of the plates before the meeting.

MDDC-948 Stars in Photographic Emulsions Produced by Particles Accelerated by the Cyclotron, by E. Gardner, 1 p., June 12, 1947. (BP-71) (See also Physical Review Vol. 72, p. 743, October 15, 1947).

This is an abstract only. See MDDC-1077 for the complete report.

MDDC-949 Hydrolytic Behavior of Plutonium (VIO. II. A Note on the Analysis of Barium Polyplutonate, by L. H. Gevantman and K. A. Kraus, 9 p., March 1947. (MonN-270).

Through acid-base titrations it was found that the precipitate resulting from the addition of barium hydroxide to a Pu(VI) nitrate solution is probably a complex barium polyplutonate, with an average composition of approximately $Ba_{0.35}PuO_2(OH)_{2.7}$.

MDDC-950 Viscosities and Densities of Fluorolube Oils, by H. M. Haendler, L. L. Burger, Z. D. Sheldon, and E. J. Barber, 19 p., April 28, 1943. (A-702).

Since the viscosity-temperature relationships of fluorocarbons are somewhat unusual, when compared to hydrocarbons, for example, it was decided to measure the viscosities, at several temperatures, of various fluorolube oils. The calculation of the viscosity of a blend of oils is at best an uncertain operation, varying considerably with the method used. A comparison of various methods was made, in order that reasonably accurate values might be assumed for theoretical composites. The densities were measured at corresponding temperatures for use in converting viscosities, and for their value, per se.

Results are tabulated and discussed and a viscosity temperature chart is included.

MDDC-951 Angular Distribution of Neutrons from Targets Bombarded by 190 Mev Deuterons, by A. C. Helmholz, E. M. McMillan, and D. C. Sewell, 15 p., June 4, 1947. (BP-74) (See also Physical Review Vol. 72 p. 1003-1007, December 1, 1947).

It was found that 190 Mev deuterons striking a thin target produce a beam of neutrons concentrated about the forward direction of the deuterons. The angular distribution of intensity in this beam was studied, using as target materials Be, Al, Cu, Mo, Sn, Ta, Pb, and U. The shape of the distributions is represented approximately by the function $(1 + a\theta^2)^{-3/2}$, and the measured widths in

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radians between points of half intensity can be given approximately as 0.155 + 0.00060 Z, where Z is the atomic number of the target material. It is pointed out that these data fit within a few per cent a simple theory of neutron production, according to which the proton is "stripped" from the deuteron by striking a target nucleus, leaving the neutron free.

This document is an abstract. For the complete report see MDDC-1081.

MDDC-952 Description of and Instructions for Operation and Maintenance of a New Model Gamma Ray Pocket Survey Meter, by O. G. Landsverk, 11 p., August 22, 1945. (CP-3134).

A quartz fibre type of instrument has been developed which is light in weight, of convenient pocket size and very rugged. Because of its ability to stand rough handling, it is particularly adapted to field work. However, it will do accurate work if it is carefully calibrated and used with a stop watch. It has an almost linear scale and will measure rates of radiation up to ten roentgens per hour with no observable loss of collection. Five units have been completed and tested. They have proved very satisfactory.

The mechanism of the instrument is described in detail and drawings and photographs are included.

MDDC-953 A Simple Demonstration of Resonance Scattering, by A. Langsdorf, Jr. and W. Arnold, 4 p., n.d., decl. 5/7/47.

Experiments demonstrate the existence of the scattering resonance both by activation of foils and by use of a BF_3 filled ion chamber detector, using neutrons scattered from a beam brought out of the Argonne heavy water pile. Results demonstrate that in the three elements tested - Au, Ag, In, - the scattering resonance has a magnitude of at least one hundred times 10^{-24} cm^2/atom, or over ten times the normal scattering cross sections found for these elements.

For specific data see abstract of MDDC-797.

MDDC-954 The Metabolism of Short-Lived Air-Borne Fission Products, by H. C. Lanz and J. D. Teresi, 38 p., May 1945. (CH-2844).

A fission recoil apparatus has been constructed in which uranium foil is subjected to neutron bombardment in the pile. Gas passing over the foil picks up the fission recoil atoms and carries them to animal exposure chambers and measuring equipment located outside the pile shield. The time taken for an atom to go from the foil to the exposure chamber (hold-up time) varied from 1.8 to 30 sec. A special ionization chamber was developed to measure the activity, which varied from 17 to 0.5 μc/cc. It has been shown that this gas contains not only the noble gas fission products but also all fission products which normally exist in the solid state.

Rats and mice exposed to this gas in an exposure chamber suffer damage and die, but no more so than would be expected from the amount of external gamma radiation which they received while in the exposure chamber.

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A special apparatus was constructed which would allow rats to breathe the gas without receiving external radiation. Rats receiving exposures of 8 hours per day for 5 consecutive days received burns of the mouth and upper respiratory tract. Some of these animals lived but most of them died, apparently from starvation because of failure to eat.

Metabolism experiments have shown that of the material that is inhaled, about 25% goes to the skeleton and is excreted very slowly; about 8% stays in the lungs and is excreted slowly; about 6% goes to the liver and is slowly excreted; and the remainder is excreted with moderate rapidity. The highest specific activity is found in the thyroid.

A histological study of tissues of animals sacrificed at various times following exposure has shown that the most severe treatment possible with this apparatus has failed to produce any detectable tissue damage which could be attributed to internal deposition of radioactive materials. Radioautographs showed that the activity was deposited uniformly over the bronchial and alveolar surfaces.

It was concluded that for short-lived air-borne fission products the hazard is very much greater from external radiations than from internally deposited radioactive materials.

MDDC-955 Cryoscopic Determination of Molecular Weights of Fluorocarbons Using Unsym-Difluorotetrachloroethane as Solvent, by I. Litant, 2 p., October 26, 1943.

Experimental work is reported on the determination of a new molecular freezing point depression constant (K_f) for unsym-difluorotetrachloroethane, and the use of the new constant in the determination of the molecular weights of a number of fluorocarbons. This compound combines an extraordinarily large molecular freezing point depression with excellent solvent power for many organic compounds.

The use of this solvent, one of the group of compounds known by the trade name of "Freon", has been suggested for use in the determination of molecular weights. A K_f for this compound of 38.6 using naphthalene and p-dichlorobenzene was previously reported.

Results:

Solute	$\frac{s}{S}$	K_f
Naphthalene	0.0126	36.9
p-dichlorobenzene	0.0144	37.7
diphenyl	0.0099	38.1
benzophenone	0.0082	38.0
ϕ-xylene	0.0202	37.4
		37.6 ± 0.4

The attempted use of ϕ-heptane and ϕ-methylcyclohexane in these determinations was unsuccessful due to their extreme volatility, causing consistent low results. ϕ-cetane was the only fluorocarbon that proved to be too insoluble at the experimental temperatures.

MDDC-956 Character of the Radiation Field and Shielding at the 184" Cyclotron, by B. J. Moyer, et al., 9 p., n.d., decl. 7/9/47 (BP-76).

The present cyclotron shielding is shown in plan view by a drawing. A two-foot roof of concrete completely covers the enclosure. Besides the neutron beam cone from the probe there was found to be a general spray of neutrons due to the deuteron beam grazing the interior of the dee. Consequently, fast neutrons are projected in considerable intensity throughout 180° of azimuth. Observations concerning the shield are summarized as follows:

(1) The fast neutron beam is readily detactable after $5\frac{1}{2}$ ft of concrete. Radiation level readings in the center of the beam cone outside the shield are 10 to 20 times those in the building at large. Additional absorption experiments and the existence of a paraffin transition effect show the persistence of a fast, directed beam.

(2) With an ionization reading of 24 r/hr in the center of the neutron beam cone 1 ft outside the tank wall (9-3/4 ft from the probe), the ionization just outside the shielding in the center of the beam is 10 mr/hr, while the general building areas are 0.5 to 1.5 mr/hr. These quoted measurements are made with Al-walled ionization chambers, and correspond to a deuteron beam of about 0.2×10^{-6} amp.

(3) Above the concrete roof under the same beam conditions the radiation level averages 25 mr/hr, but the contribution to general building radiation from "skyshine" and building roof back-scattering is estimated from certain experiments to be not over 10%.

(4) Measurements with a BF_3 proportional counter have indicated diffusion of slow neutrons through various access openings from the enclosure. Absolute measurement of slow neutron flux outside the concrete gives values of the order of 10^3 cm^{-2} sec^{-1} for beam strengths similar to that mentioned above.

It was considered of interest to measure the shielding properties of such elements as could be conveniently secured in the form of slabs. Results, for thicknesses only of several inches, are displayed for graphite, paraffin, aluminum, copper, and lead. The transition effects occur as the neutron beam approaches equilibrium with the secondary and scattered particles produced in the absorbing medium.

Thus since Pb yields fewer ionizing secondaries (protons) capable of penetrating the ionization chamber walls than does the iron of the cyclotron tank wall (plus a few feet of air), it displays a negative transition effect. Paraffin yields a transition increase of 60% following Fe, and 100% following Pb with similar geometry.

Experiments using carbon disc detectors sandwiched between slabs of absorber gave exponential attenuation with half-value determinations which were generally made with better precision than those with ionization chambers. Tabulation of results is shown.

The practical deductions with regard to shielding materials are that substances should be used which combine high density with low atomic number. Among convenient and practical materials concrete is recommended.

MDDC-957 Cobalt 61 Radioactivity, by T. J. Parmley and B. J. Moyer, 1 p., n.d., decl. 4/47. (See also Physical Review, Vol. 72, p. 82, July 1, 1947.)

This is an abstract of MDDC-859.

MDDC-958 The Use of Ion Exchanger for the Determination of Physical Chemical Properties of Substances, Particularly Radiotracers, in Solution. II. The Dissociation Constants of Strontium Citrate and Strontium Tartrate, by J. Schubert and J. W. Richter, 11 p., December 1946.

The ion exchange method was used to measure the dissociation constants of strontium citrate and strontium tartrate. All the measurements were made at 25°C and at a pH of about 7. The ionic strength of the solutions was furnished entirely by ammonium salts since the total concentration of radiostrontium was of the order of 10^{-11} mole per liter. The pK_c for strontium tartrate was found to be 1.69 when the total ammonium ion concentration in solution was 0.16 mole. Under the same conditions the pK_c of strontium citrate was equal to 2.81. When the total ammonium ion concentration was 1.05 moles per liter the pK_c of strontium citrate was 2.18. These results are in excellent agreement with the values reported in the literature.

Supplementary studies showed that as the pH increased from 5 to 8 there was a steady and marked increase in the amount of radiostrontium adsorbed by the cation exchanger. This result emphasizes the importance of pH control in cation exchange reactions.

MDDC-959 Energy of Fission Fragments of U^{235}, U^{238}, Pu^{239}, by T. Snyder, 2 p., October 25, 1945. (LADC-254).

A preliminary experiment to measure the energy distribution of fission fragments from U^{235}, U^{238}, and Pu^{239} is described. The measurements were carried out in a parallel plate ionization chamber.

MDDC-960 Six Inch Diffusion Pump, by Williams, 5 p., n.d., decl. 5/9/47. (LADC-343).

Engineering drawings of the components and completed assembly of a six inch vacuum diffusion pump.

MDDC-961 Four Inch Pump Valve, by Wilson, 3 p., n.d., decl. 4/3/47. (LADC-344).

Engineering drawing of component parts and complete assembly of a value for a four inch vacuum diffusion pump.

MDDC-962 Effects of Radiation on Materials, by A. O. Allen, 31 p., n.d., decl. 5/20/47.

A survey is presented of the behavior of substances of different types when exposed to ionizing radiations. All covalently-bonded substances suffer chemical changes, with about four molecules usually reacting per 100 ev of radiant energy absorbed. The types of molecular mechanism involved in such changes are discussed. With simple compounds, the reactions are reversible, and sometimes proceed to a small extent only. Organic compounds give extremely complex mixtures

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of widely varying molecular weight, and no method has yet been found to channel the reactions into any desired direction. Water decomposes into hydrogen and oxygen, but the maximum gas pressure which can be produced is limited by a back reaction and varies greatly with traces of impurity and with the type of radiation used. Materials in aqueous solution are rapidly oxidized, reduced, or decomposed by free radicals formed from decomposition of water molecules; examples are presented from the published literature and reaction mechanisms discussed. When two solutes are presented simultaneously, one is usually attacked preferentially; such "protection" is important in biological systems. Colloidal solutions show periodic fluctuations of electrophoretic mobility which are not understood.

The possibility of radiation effects on metallic corrosion rates is mentioned. Solids containing covalent bonds may or may not be decomposed as a result of ionization. Metals and ionic solids are not greatly affected by electrons, but energetic heavy particles (such as neutrons or alpha rays) will cause atomic displacements within these materials as a result of elastic collisions (Wigner effect). A brief qualitative theoretical discussion of this effect is given, and some calculations of Seitz are mentioned on the number of atoms which should be displaced by a fast neutron in passing through a material of low atomic weight. These calculations do not tell what will happen to the material, as many of the displaced atoms may later return to normal positions. It has been disclosed that detectable changes in physical properties do occur in graphite under neutron bombardment, but the extent of such changes is a matter which must be determined empirically for each substance.

MDDC-963 Progress Report, Proton Cyclotron R. F. Group, by B. Anderson, J. Riedel, J. Woodyard, and L. Wouters, 23 p., n.d., decl. 6/6/47. (BP-67).

The dee geometry chosen for the 184" proton cyclotron is electrically equivalent to a capacity-loaded quarter wavelength line. Model tests indicate that the required maximum tuning capacity is considerably less than calculated for such a line, due to an inductive effect introduced by locating the variable capacitors at the corners.

Three possible forms of oscillators for use on a wide band system are discussed. Calculations for dee dimensions, capacitor size and power requirements are summarized in the second section.

MDDC-964 184" Cyclotron Oscillator Capacitance Measurements, by R. L. Anderson, 1 p., March 18, 1947.

The complete contents of the report are reproduced here.

The capacity of the oscillator plate to ground was investigated. The oscillator housing was separated from the transmission line housing, and the oscillator plate coupling loop was disconnected at its grounded end. The water lines running through the loop were disconnected at their entrance into the loop. The G.R impedance bridge leads were connected to the 9C21 tube water jacket and to the oscillator housing. For accuracy an oscilloscope was used in balancing the bridge.

The plate to ground capacity with coupling loop disconnected was 113 $\mu\mu$f. The plate to ground capacity with coupling loop disconnected and two 50 $\mu\mu$f vacuum capacitors added as in normal run condition was 219 $\mu\mu$f. The grid circuit contains 15-50 $\mu\mu$f vacuum capacitors in parallel (calculated)

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-750$\mu\mu$f. The filament circuit contains 10-50 $\mu\mu$f vacuum capacitors in parallel (calculated)-500$\mu\mu$f. It was not deemed necessary to measure the grid or filament circuits. The measurements were made with G-R Impedance Bridge type 650-A Serial No. 1977 and are $\pm$ 2 $\mu\mu$f. Lead capacity of 29 $\mu\mu$f has already been deducted.

MDDC-965 Distribution of C^{14} in Photosynthesizing Barley Seedlings, by S. Aronoff, A. Benson, W. Z. Hassid, and M. Calvin, 5 p., April 14, 1947. (BC-48). (See also Science, Vol. 105, p. 664-665, June 27, 1947.)

Barley seedlings, with roots (I) and without roots (II), were permitted to photosynthesize for 2 hours in an atmosphere of $C^{14}O_2$ and H. Then the plants were frozen in liquid N, powdered, and separated into 12 fractions which contained about 80% of the original radioactivity. I took up 4 times as much C^{14} as II. A third of the total C^{14} in II was present in the sugar fraction, the rest distributed fairly evenly among the other fractions. In I the sugar fraction contained only 1/4 of the total C^{14} content, but the amount of C^{14} in the organic and amino acid fractions was greater than in II.

MDDC-966 Distribution of Labeled Carbon in Sugar from Barley, by S. Aronoff, H. A. Barker, and M. Calvin, 3 p., April 10, 1947. (BC-49). (See also Journal of Biological Chemistry, Vol. 169, p. 459-460, July 1947.)

Degradation of the radioactive sugars from barley seedlings which had assimilated $C^{14}O_2$ revealed that the radioactivity was greatest in C atoms 3 and 4, intermediate in C atoms 2 and 5, and lowest in the terminal C atoms of the hexose chain.

MDDC-967 Alpha and Beta Ray Counters, by J. F. Bonner, Jr., n.d., decl. 5/28/47, 103 p.

The investigation and development of suitable high voltage supplies for portable G-M counters is described. The blocking oscillator circuit is believed to be the simplest and most efficient circuit yet developed.

The design and construction of a simple alpha counter for the measurement of foil samples is presented. The circuit uses no batteries and is operated entirely from the A-C line. The noise level is sufficiently low so that foil samples may be counted accurately.

Several of the circuits developed for use with the alpha counter can be used with little or no modification with a G-M counter. A simplified quenching circuit and an oscillator for producing the required high voltage is described.

Circuit diagrams and graphs are included.

MDDC-968 Neutron Cross Section Studies with the Rotating Shutter Mechanism, by T. Brill, H. V. Lichtenberger, January 27, 1947. (See also Physical Review, Vol. 72, p. 585-590, Oct. 1, 1947).

It has been possible to extend the usefulness of the rotating shutter mechanism of Fermi, Marshall, and Marshall for velocity selection of neutrons by increasing the number of photoelectrically activated gate circuits. With the modifications described, data can be obtained simultaneously in six well resolved velocity intervals. In this way the cross sections of gold, gadolinium, and dysprosium are measured as a function of velocity for low energy neutrons.

The following figures are included: rotary shutter neutron velocity selector; total slow neutron cross section of gold as a function of energy; slow neutron cross section of gadolinium; slow neutron cross section of dysprosium; speed control circuit; early photocell and amplifier system (one channel); improved photocell and amplifier system; gate circuit; and electronic tachometer.

MDDC-969 184" Cyclotron Pumping Speed Test, by W. M. Brobeck, 3 p., February 27, 1947.

A variable air leak was let into the tank by opening the house vacuum line into the probe air lock which was open to the tank. Several base pressures were established with this leak and a rate of rise was taken at each base pressure. The pumping speed at minimum base pressure was determined from the slope of the curve of rate of rise vs. base pressure, using the following formula:

$$\text{speed} = \frac{\text{rate rise}}{\text{base pressure}} \times \text{volume of tank.}$$

The volume of the tank up to the diffusion pump valve seats was calculated from the tank drawings. Volume = 1605 cubic feet = 45,400 liters.

Results tabulated and graphed.

MDDC-970 The Decarbonylation of Ethyl Pyruvate, by M. Calvin and R. M. Lemmon, 2 p., April 15, 1947 (BC-50).

One aspect of the mechanism of the thermal decarbonylation of ethyl pyruvate with the aid of C^{14} was investigated. Pyruvic ester labelled in the α carbon atom was synthesized by the following sequence of reactions:

$$CH_3MgI + C^{14}O_2 \xrightarrow{H^+} CH_3\ C^{14}O_2H \xrightarrow{PBr_3} CH_3\ C^{14}O\ Br$$

$$CH_3\ C^{14}O\ Br \xrightarrow{Cu_2(CN)_2} CH_3\ C^{14}O\ CN \xrightarrow[H_2O]{[H^+]} CH_3\ C^{14}O\ CO_2H \xrightarrow[H^+]{EtOH} CH_3\ C^{14}O\ OEt$$

The ester, after purification by distillation, was subjected to thermal decomposition. Traces of CO_2 were removed from the CO formed, and the CO was burned to CO_2, absorbed in NaOH, and precipitated as $BaCO_3$. The radioactivity of the α carbon atom in the pyruvate was 3180 counts/min/mg C (12.9 disintegrations per count). There was no detectable activity in the CO formed in 90% yield, or in the trace of CO_2 formed. It was found in the acid obtained by hydrolysis of the pyrolytic residue. The evolved CO comes from the carboxyl group of the α-ketoester.

MDDC-971 A Rapid Method for the Determination of Nitrogen Oxides in Air, by J. F. Flagg and R. Lobene, 6 p., September 5, 1944. (II-188-2196 [M-1576]).

A method was devised for adsorbing NO_2 on silica gel, treating with diphenylamine, and comparing the color with standards.

The method is applicable to air-gas mixtures containing from 1-50 p.p.m. of NO_2.

Advantages claimed are sensitivity and speed, requiring only simple apparatus and reagents. Disadvantage lies in only moderate accuracy.

MDDC-972 A Neutron Detector Having Uniform Sensitivity from 10 Kev to 3 Mev, by A. O. Hanson, J. L. McKibben, 17 p., February 11, 1947. (See also Physical Review, Vol. 72, p.673-677, Oct. 15, 1947)

A neutron detector having approximately uniform sensitivity from a few kilovolts neutron energy to a few million volts energy is described. The arrangement known as a long counter consists of a paraffin cylinder about 10" outer diameter x 12" long surrounding a long baron proportional counter. Sensitivity curves are given for two of the best arrangements. The response is flat over the above range to about 10%.

MDDC-973 Component Analysis of Small Uranium Samples, by J. W. Kennedy and E. Segre, 30 p., March 26, 1943. (Spec. 9 UCRL).

A detailed account of present procedures used for the component analysis of small amount of uranium.

Details are given for the measurement of the mass, the alpha-activity and the slow neutron produced fission of the sample. Calculations and statistical errors are considered.

Drawing of the following are included: ionization chamber; linear amplifier; power supply, and scaling circuit; pulse generator; and lead shielding for Ra Be source.

The photographs are of an ionization chamber and linear amplifier, and of a power supply and scaling circuit.

MDDC-974 2" Packless through Vacuum Valve, by R. Krohn, 2 p., n.d., decl. 5/20/47. (LADC-404). (See also Review of Scientific Instruments Vol. 18, p. 682-683, September 1947)

A photograph and explanatory note of a 2" packless through vacuum valve designed for use on accelerator tubes where a through type valve is needed to allow a line of sight path for ion beams.

MDDC-975 The Beta-Ray Spectrum of C^{14}, by P. W. Levy, 3 p., n.d., decl., 5/28/47. (See also Physical Review Vol. 72, p. 248, August 1, 1947)

A 180° beta-ray spectrometer of 10 cm radius, using a Geiger-Mueller Tube as the detecting device, has been used to investigate the continuous beta-ray spectrum of the 4700 year C^{14} activity. A very thick source was used because of the long half-life and low concentration of C^{14} in the available material. The spectrum obtained with this source has only one component and has a maximum energy of .154 Mev. No conversion electron lines appear.

The maximum energy of the beta-ray spectrum was determined from the Kurie plot, which was constructed from that part of the spectrum high enough in energy so that absorption in the window of the detecting G.M. Tube is negligible. The Kurie plot is straight, and, if it were not for the unusual thickness of the source, this evidence could mean that the spectrum was free from large disturbing effects.

MDDC-976 X-Rays Associated with U-234, by R. L. Macklin and G. B. Knight, 5 p., December 24, 1946. (C-66) (See also Physical Review Vol. 72, p. 435, September 1, 1947)

The observation of L and M X-rays from U_{234} unaccompanied by appreciable K - X radiation is reported. The suggestion is made that these arise from recoil atoms following alpha emission.

MDDC-977 The Halogen-Metal Intercovers on Reaction and Its Application to the Synthesis of Nicotinic Acid Labeled with Isotopic Carbon, by A. Murray, III, W. W. Foreman, and W. Langham, 3 p., n.d., decl. 5/13/47. (LADC-407).

The halogen-metal interconversion reaction involving organolithium compounds has been studied as a means of introducing isotopic carbon into organic molecules having biological significance.

The extremely short reaction time required for the interconversion reaction permits the preparation of organometallic compounds having additional reactive groups, thus providing an advantage over the ordinary Grignard reaction. When the resultant organolithium compounds are carbonated with isotopic CO_2, carboxylic acids result that are labeled in the carboxyl group with isotopic carbon.

The halogen-metal interconversion reaction between n-butyllithium and 3-bromopyridine has been used to prepare nicotinic acid labeled both with C^{13} and C^{14}. The material labeled with C^{14} had a specific activity of about 8 microcuries per mg. The nicotinic acid labeled with C^{13} was 0.9 isotopic per cent C^{13}.

The interconversion reaction between n-butyllithium and p-bromoaniline resulted in a 12% yield of pure p-aminobenzoic acid subsequent to carbonation with $C^{12}O_2$.

MDDC-978 5.3-Day Element 61, by G. W. Parker, et al., 2 p., n.d., decl. 5/28/47. (ANL-AJD-161). (See also Physical Review Vol. 72, p. 85, July 1, 1947)

A sample of fission 61, shown by mass spectrographic analysis to be predominantly mass 147, was irradiated by slow neutrons in the Clinton Pile. After bombardment, a 5.3-day 61 activity was found to be present. The cross section for this action was approximately 60 x 10^{-24} cm^2. The radiations from this sample, as determined by absorption curves, were a ca 2.5 Mev β^- and a 0.8 Mev γ.

To verify that the reaction involved was actually (n,γ) and hence that the mass of the 5.3-day element 61 and 148, a portion of the sample was analyzed by means of a mass spectrograph. After separation, active isotopes were found at masses 147 and 148. To verify that the activity at mass 148 had a half-life of 5.3 days, the photographic plate upon which the separated isotopes were deposited was placed successively against various parts of a larger photographic plate for times calculated to give equal intensity in the 148 position if its half-life were 5.3 days. Five exposures were taken for successive times of 33.2, 40.7, 52.3, 72.3, and 122 hours. Upon development this large plate showed equal blackening at mass 148 and increasing blackening for successive transfers at mass 147. Thus the mass of the 5.3-day element 61 is 148.

MDDC-979 Adrenal Response to Total Body X-radiation by H. M. Patt, M. N. Swift, E. B. Tyree, E. S. John, 19 p., March 15, 1947. (See also The American Journal of Physiology, Vol. 150, p. 480-487, Sept. 1947)

Adrenal, spleen and kidney weights and adrenal cholesterol content are determined in a timed sacrifice series following total body X-radiation of rats at 200 r, 650 r, and 900 r.

A significant reduction in adrenal cholesterol is obtained at 3 to 6 hours after exposure to either 650 r or 900 r whereas only a slight decrease is noted at 200 r. After the initial decrease with the mid-lethal dose (650 r), adrenal cholesterol rises markedly reaching a level some 100 percent above the normal one week following irradiation. Animals dying after 650 r show a greatly decreased adrenal cholesterol. With 900 r cholesterol falls more or less progressively until death when an 80 percent reduction is observed.

Adrenal weight is elevated significantly 2 days after X-radiation with either 650 r or 900 r. The adrenals continue to show a rather progressive increase in weight at subsequent sacrifice periods. A considerable increase in weight (100-130 percent) is seen at death. The increased adrenal size is not a result of an increase in water content. After 200 r, there is little change in adrenal weight.

A decrease in weight of the spleen is seen at all dose levels. Spleen continues to decrease in size until death when it is roughly one-fourth of the control weight. Kidney weights which were included as controls do not change significantly following irradiation.

Evidence is cited which suggests that the described changes in adrenal cholesterol and adrenal weight reflect an altered adrenal cortical activity. The latter may, therefore, provide a physiological mechanism for some of the changes observed after X-radiation.

Tables and graphs are included.

MDDC-980 Cloud Chamber, Cloud Chamber Tank, Assembly, by Radiation Laboratory, 1 p., June 7, 1946.

A half scale engineering drawing and parts list of a cloud chamber tank assembly.

MDDC-981 Cloud Chamber Vacuum Tank and Valve Seat Assembly, Radiation Laboratory, 1 p., June 7, 1946.

A full scale engineering drawing and parts list of a cloud chamber vacuum tank and valve seat assembly.

MDDC-982 184" Cyclotron Radiation Measurement of Breech Load Probe head, by A. Reyenga, 4 p., n.d., decl. 5/23/47.

This experiment was performed to measure and plot the radiation intensity across the face of the probe head, thereby noticing the points of high intensity and learning how much radiation is lost because of the beam not striking the foil.

The experiment was set up, as shown on the sketches, starting just below the zero position and moving the probe head up past the 1/8" slot in small steps. The probe was set at 81" radius during the bombardment.

The results shown by the graph indicate a high intensity point (21 mr/hr) on the top outside edge of the copper foil holder, another high intensity point (18.5 mr/hr) on the foil just above the median plane, and another high intensity peak (13 mr/hr) on the lower outside edge of the copper foil holder.

MDDC-983 The University of California Synchro-Cyclotrons, by R. L. Thornton, 25 p., July 10, 1946. (BP-23).

A general description of the California cyclotrons is given. The discussion is on an elementary level and indicates the scope and function of the various components described in detail.

MDDC-984 184 Cyclotron Vertical Beam Oscillations in the Region of 82" Radius, by J. Vale, 8 p., February 26, 1947.

In the operation of the 184" cyclotron, the beam did not go out to the expected 85" radius. Experiments were set up to prove the theory that the beam did not go beyond a radius of 82" because of vertical oscillations building up in the vicinity of this point. Autographs indicated a rapid spreading vertically of the beam at about $81\frac{1}{2}$" and showed that the vertical spreading is large enough so that most of the beam gets caught by the dee at this point. Prints of the autographs are included in the report.

MDDC-985 Nioxime: A Reagent for Nickel, by R. C. Voter, C. V. Banks, and H. Diehl, 16 p., n.d., decl. 5/29/47.

The compound, 1,2-cyclohexanedionedioxime, designated Nioxime, is similar to dimethylglyoxime in yielding scarlet and yellow precipitates with nickel and palladium which can be used for the gravimetric determination of these metals. It is soluble in water in contrast to dimethylglyoxime so that its use is theoretically unaccompanied by danger of contaminating the precipitates with excess reagent or of solubility loss by the addition of alcohol. On the other hand nioxime is a more powerful reducing agent than dimethylglyoxime which introduces some complications in its use.

One part of nickel in ten million may be detected with the reagent. The precipitation of nickel nioxime is complete at pH values of three and greater, and the precipitation may be made from a solution of various anions, chloride, sulfate, perchlorate, nitrate, acetate, tartrate and sulfosalicylate. The precipitation effectively separates nickel from a variety of metals including zinc, beryllium, uranium, aluminum, the alkali and alkaline earth metals, manganese, cadmium, antimony and arsenic. Attempts to separate nickel from iron failed, as no suitable complexing agent for the latter was found which would prevent the precipitation of the iron, and not interfere in the determination of the nickel.

MDDC-986 Frequency Modulated Cyclotron Characteristics, by B. T. Wright and J. R. Richardson, 1 p., April 30, 1946. (BP-13).

The complete text follows.

The beam current dependence on various operational parameters was compared with theory; those investigated include the following: Modulation Frequency: For each dee voltage an optimum modulation frequency exists when the average energy gain per turn required to keep the natural frequency of the ions equal to the applied frequency equals one-half the available energy gain per turn. Pressure: All loss due to scattering occurs at energies < 300 kv; doubling base pressure in operating range reduces beam fourfold. Dee Voltage: Doubling dee voltage in range 3 - 5 kv peak triples beam for equivalent modulation frequencies.

At dee voltage 11.5 kv, modulation rate 1900 cycles per second, pressure 3.6×10^{-5} mm Hg, 2.9 microamperes (D. C. average) of undeflected 8 Mev deuterons have been produced.

Some ions start on one modulation cycle and arrive at the final radius as many as three modulation cycles later. These ions, on being lost from the acceleration of the first cycle at a certain radius, continue rotating near that radius until the next cycle, when some of them, having the proper phase, will be picked up and further accelerated.

MDDC-987 184" Cyclotron Synchroscope Beam Pictures on Two Probes, by F. W. Yeater, Jr, 8 p., February 26, 1947.

An experiment was performed in an effort to determine more definitely that the peaks, or "pips", shown in synchroscope photographs of the beam current are caused by precession of the beam.

Several photographs were taken under the following conditions:

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Magnet current	1500 amps
Dee voltage (RF)	16 kv
Capacitor speed	240 rpm
Pulse length	5 microseconds

The usual beam pattern of two to three pips was obtained at several probe radii; namely, 22", 28½", and 35". Then, when the auxiliary probe was positioned to catch some of the accelerated ions, the beam pattern was altered to show the relative amplitudes of beam current in the two probes and the phase relation of those currents.

MDDC-988 The Measurement of Short Time Intervals by L. W. Alvarez,1 p., April 29, 1947. (See also Physical Review Vol 72, p. 741, October 15, 1947).

This is an abstract and the complete text is reproduced here.

Modern "spectrum analyzers" present on a cathode ray tube the frequency spectrum of repeated video pulses. The same pattern could be shown for a single pulse if a number of tuned receivers were used with appropriate delay lines in their outputs. For the gaussian pulse from a 931 electron multiplier, the spectrum would be gaussian with large signal-noise ratio beyond 1000 mc. Receiver gains could be adjusted to show an apparently flat spectrum from 0 to 1000 mc. for a single pulse. Then if two pulses with amplitude ratio n occurred with time delay T, the spectrum would have the form $1 + n \cos 2\pi fT$. (For $T = 2 \times 10^{-9}$ sec, minima at 250 and 750 mc.) By observing this "interence pattern," one measures T. At frequency f, the phase shift of the pattern is $2\pi f \Delta T$, independent of T. (For $f = 10^9$ and $\Delta T = 10^{-10}$ sec, $\Delta\phi = 36°$). With receiver spacing ΔF proportional to f, the minimum detectable ΔT is a constant fraction of T and can be 0.1 in practice. ($\Delta T = 10^{-10}$ for $T = 10^{-9}$). Receiver bandwidth has no effect on ΔT. which is determined by f max. The method is mathematically equivalent to Michelson's double slit star diameter experiment. Measurement will be by analysis of photographs, but automatic methods could be devised.

MDDC-989 Impregnation Mounting Method for the Metallographic Preparation of Porous Metal Bodies, by R. P. Angier, March 28, 1947, 1 p.

The complete report is reproduced herewith.

The method consists of impregnating the porous metal body with a monomeric plastic, polymerizing the monomer in a situ with the aid of a catalyst, an accelerator and heat. There results a dense, hard, transparent metallographic mount encasing the porous body. The metallographic advantage is that the dense, hard, transparent polymer preserves the porous structure during metallographic preparation.

Desirable materials for use in this method are methyl-methacrylate monomer, benzoyl or lauroyl peroxide catalysts and American Cyanamid's Accelerator X-266.

MDDC-990 Heat Transfer in Sphere Beds, by R. Bentley, F. Johnson, and R. Maurer, 18 p., July 4, 1945. (CP-3090).

The rate of solution of benzoic acid in water was determined for a system consisting of a bed of acid spheres with water flowing through the interstices of the bed. It was proposed to use the results to estimate the heat transfer between a sphere bed and a liquid coolant. The equation proposed for this purpose was

$$St = 2.36 \times 10^{-1} Re^{-0.3} Sc^{-0.6}$$

where St, Re, and Sc are the Stanton, Reynolds, and Schmidt numbers.

MDDC-991 The Effects of Irradiation on the Blood and Blood Forming Tissues, by S. T. Cantril, L. Jacobson, and J. J. Nickson, 66 p., January 11, 1943. (CH-410).

A review is given of the effects of external whole body and local irradiation in man and experimental animals. Internal irradiation by radioactive substances in man and experimental animals is considered.

The lymphocyte and its predecessors are the most sensitive cells in the blood system. The characteristic response is a diminution in the number of circulating cells or an increase in the number of lymphocytes.

The red blood cells are relatively insensitive to the effects of irradiation except for long continued exposure.

Platelets are a fairly sensitive index of irradiation damage to the blood system in the acute exposure of whole body irradiation.

Monocytes are of importance only in evaluating the more extreme degrees of irradiation change. When complete monocytosis occurs radiation damage is severe.

MDDC-992 Safety Rules and Procedures Concerning Activity Hazards, by S. T. Cantril, 39 p., June 1944. (CH-1864 [A-2866]).

The following sections are covered in the report: function of the subcommittee on activity hazards, general safety rules and procedures, radiation safety monitoring, maintenance, transportation of active materials or equipment, radium sources, classification of injuries from over-exposure to activity in any form, and rules and procedures issued by separate areas or locations.

MDDC-993 Tolerance to Whole Body Irradiation of Patients With Advanced Cancer, by L. F. Craver, December 13, 1945 20 p.

In 8 cases of advanced metastatic malignant neoplasm of humans exposure of the entire body to 180 KV heavily filtered x-rays at an intensity of 10 r/day (0.85 r/hr) or 15 r/day (1.65 r/hr), for total doses of 150 r and 161 r in 2 cases, and 300 r in 6 cases, was not followed by clinical or hematological effects ascribable to the radiation, either during or within a month after cessation of exposure.

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In 5 cases followed from 4 to 19 months after exposure there was, likewise, no deterioration in blood count of clinical state that could not reasonably be ascribed entirely to the progress of the neoplastic disease.

Since individuals so seriously ill of cancer could withstand up to 300 r of total body 180 KV heavily filtered roentgen exposure, administered in a period of from 20 to 30 days, with no appearance of subsequent ill effects other than those apparently caused by the progress of the disease, such doses of radiation should be well tolerated by healthy persons.

MDDC-994 Transmutations with High Energy Deuterons and Helium Ions in the 184-Inch Cyclotron, by B. B. Cunningham, et al., 2 p., April 28, 1947. (BC-51).

The complete report is reproduced here.

The successful operation of the Berkeley 184-inch cyclotron to produce useful beams of deuterons and helium ions of approximately 200 and 400 Mev, respectively, has made possible the radiochemical identification of many of the transmutation products of nuclei excited to very high energies. Products with considerably lower atomic number than the target were observed in all cases. With 200 Mev deuterons on $_{33}As^{75}$ activities were found representative of all elements from $_{34}Se$ to $_{25}Mn$ with lower elements not excluded. Both negative beta-particle and positron (or orbital electron capture) activities are noted, indicating reactions both of multiple neutron ejection and multiple charged particle ejection. With deuterons on $_{51}Sb^{121}$ and ^{123} both 6.7-hour $_{48}Cd^{107}$ and 2.5-day $_{48}Cd^{115}$ were produced with $_{33}As^{75}$ cobalt activities tentatively assigned to $_{27}Co^{55}$ or 27 Co^{54} ($\sim$ 12 hr) and 27 Co^{61} ($\sim$ 1.8 hr) were found.

For the formation of light isotopes, several different reactions are possible since in most cases the products will not be shielded from formation through a chain of short-lived positron (or orbital electron capture) ancestors following the ejection of different combinations of neutrons and charged particles in the primary reaction. As an example from deuterons on $_{29}Cu^{63}$ and 65, the formation of a new 8-hour iron positron emitter assigned to $_{26}Fe^{52}$ may be represented by the expression, $Cu^{63}(d,4z13a)Fe^{52}$, which indicates that four units of charge and thirteen mass units are lost in arriving at the product. In the case of the heavier isotopes it may be possible to write somewhat more definite reactions of the type $Sb^{123}(d,2\alpha2n)\ Cd^{115}$ and As^{75} (d, $p3\alpha3n)Co^{61}$, although negative beta-particle emitting parents are possible.

Uranium was bombarded with 400 Mev helium ions and a wide range of activities were identified both in the heavy element region and in the region of the fission products. Representative of the heavy isotopes observed were $_{88}Ra^{223}$ (AcX), $_{88}Ra^{224}$(ThX), and $_{85}At^{211}$. The fission product distribution is characterized by a much shallower dip between the maxima than is the case for slow neutron fission, and the yields of the lightest observed fission products are much higher.

MDDC-995 Oral Conditions in Workers Chronically Exposed to Dilute and Anhydrous Hydrofluoric Acid, by P. P. Dale and H. B. McCauley, 11 p., November 1944. (II-188-2556 from M-1595)

Fluoride urinalyses obtained from spot urine samples of forty subjects, thirty-three exposed and seven unexposed, revealed that:

There is no apparent correlation between age of employee, years of exposure to F_2 and the fluoride urinary excretion.

There is no correlation between radiographic changes of the jaws and the fluoride excretions.

Considerable variation in fluoride urinary output in the exposed subjects (1.70-49.3 mgs F) which were consistently greater than the unexposed (less than 1 mg F per liter of urine).

The F_2 workers excreted high urinary fluoride as a result of their exposure and indicated definite bodily storage.

Since urinary fluoride excretions parallel the intake of the preceding 24 to 72 hours, the single fluoride urinalyses obtained are no index of their daily exposure. Therefore, the individual's absorption of volatile fluorides and their excretion may vary daily, depending upon the exposure.

MDDC-996 Maintenance Experience and Development on the "California" Scaler, by W. T. E. Elmendorf, 9 p., March 3, 1944. (CP-1303 [A-1861]).

The California circuits are composed of three type A beta circuits using Neher-Harper quenching for mica window G-M tubes and five type B alpha circuits with type A amplifiers. (Drawings of the circuits are included.) There are three magnetic type alpha chambers and two standard alpha chambers used with the five alpha sets. A general discussion of the operation of the circuits is reported and suggestions for modifications are made.

MDDC-997 Cutie Pie, A Portable Radiation Instrument, by H. U. Fisher, C. O. Ballou, 11 p., September 22, 1945.

A portable beta and gamma radiation meter of exceedingly small dimensions and weight has been developed.

The circuit, using one Victoreen V-32 tube, is the simplest electronic circuit possible for radiation work and gives high sensitivity.

The short term stability is due to a circuit which prevents emission before the cathode reaches operating temperature. Long term stability has been improved by evacuating the tube enclosure and switch.

The complete, one unit instrument, weighs four pounds two ounces, and is carried with a pistol grip. Exclusive of chamber and handle, its dimensions are 3" wide, $6\frac{1}{2}$" long, and 5" high.

The case is formed of aluminum and is designed to give excellent visibility of the meter.

Three ranges of approximately 50, 500 and 5000 mr/hr have been incorporated in the instrument.

A circuit diagram and photographs are included.

MDDC-998 Gmelins Handbook of Inorganic Chemistry, Uranium and Isotopes, System - Number 55, translated by Inez C. O'Brien from the 8th German edition, 1936, 113 p., November 27, 1944.

This translation comprises only two sections of the original German edition: the section entitled "History", page 1, and the section, "The Element", pages 39 to 82.

MDDC-999 Effects of Single Doses of X-Rays on Rabbits, by C. W. Hagen, L. O. Jacobson, R. Murray, P. Lear, 59 p., September 9, 1944.

Rabbits were exposed to 200 k v p x-rays filtered with 0.5 mm of copper and 1 mm of aluminum. Doses were measured in air within a cellulose acetate rabbit box at the position occupied by the center of the rabbit's body during exposures. Doses so measured were within 15% of the average dose received by all of the tissues of the exposed rabbits as determined by measurements in a Masonite phantom and in rabbit carcasses.

The median lethal dose (based on survival for 30 days) was 790 r $\pm$ 20 r. Heavy (older?) rabbits were more resistant to the lethal effects of x-rays than were light rabbits. Deaths occurred most frequently at one day, at 5 to 15 days and at 35 to 60 days after exposure.

Clinical effects were also most severe on the first day, at 5 to 15 days and between 35 and 60 days after irradiation. The most conspicuous changes observed were listlessness, diarrhea, excessive salivation and lachrymation during the first day, epilation, paleness, edema, diarrhea, occasional paralysis of the hind legs, and bloody discharge from the mouth at 5 to 15 days; and emaciation and diarrhea at 35 to 60 days.

After 800 r and sometimes after 400 r, rabbits lost weight for the first two days. This loss of weight was associated with a decrease in food intake. The weight changes after the first two days varied with the individual rabbit but in general consisted of one or more consecutive periods of gain and loss. The period of weight minima corresponded roughly with the periods at which deaths were most frequent.

Following single doses of 400 r and 800 r on rabbits the blood forming tissues showed the most severe damage. The lymphatic tissue showed the earliest evidence of damage (one hour) but the maximum cellular depletion of the bone marrow was greater than that of the lymphatic tissue. The small lympocytes of the hematopoietic coci appeared to be the most sensitive cells but medium lymphocytes, myelocytes, early erythroblasts and megakaryocytes were severely depleted at 800 r. Mature granulocytes, erythrocytes, plasma cells, connective tissue cells (fixed), endothelial cells, muscular cells, nerve cells and even small lymphocytes in certain locations (e.g. in the epithelium of the gut) showed no marked evidence of damage.

Epithelial tissues were in general less sensitive than hematopoietic tissues. The gut epithelial cells in the region of mitotic activity, however, showed definite degenerative changes. The germinal cells of both male and female gonads were badly damaged. The epithelia of the kidney, liver, adrenal, skin and respiratory tract were not affected.

The regeneration of blood elements was characterized by transformations from reticular cells to large lymphocytes in the early intervals (three and eight hours). There was resumption of previously inhibited mitotic activity at 8 hours but no marked hyperactivity of mitosis. In all organs there was nearly complete regeneration by 5 weeks after 800 r.

In the peripheral blood, lymphocyte levels were depressed after 50 r and heterophil counts showed changes after 100 r. Platelet levels were reduced by 500 r and were in some cases severely depressed before death after 800 r. Reticulocytes practically disappeared from the peripheral blood by 120 hours after doses of 800 r.

MDDC - 1000 Metabolism of Fission Products, by J. G. Hamilton, 45 p., August 9, 1943.

RADIO-CERIUM (Ce^{140})

Ce^{140} was prepared without carrier from Uranium fission material. The identity and purity was confirmed by suitable chemical and physical studies which included isolation and identification of the 18 minute Radio-Praesodymium daughter. A large group of animals received a solution of Ce^{140} as $CeCl_3$ by different routes of administration. Its metabolic behavior in most respects qualitatively resembles those of Yttrium and Lanthanum although it is more poorly mobilized when administered parenterally or directly into the lungs. In this respect it more closely resembles Zirconium than the rare earths.

RADIO-STRONTIUM (Sr^{85})

Radio-Strontium without carrier was found to be chiefly deposited in the skeleton whether given either orally or by intraperitoneal injection. Approximately 15% was absorbed when given by mouth and 70% retained when injected. The rate of elimination of the assimilated Strontium is slow and is less than the rate of radioactive decay of Sr^{89}.

DECONTAMINATION STUDIES

The simultaneous administration of inert Strontium with Sr^{85} diminishes the skeletal deposition by as much as 50% following intraperitoneal injection. Other measures, which included the administration of NH_4Cl, Sodium Citrate, the Parathyroid hormone, and massive doses of Vitamin D were without significant effect.

MDDC - 1001 Metabolism of Fission Products, by J. G. Hamilton, 49 p., May 13, 1944. (CH-1659[A-2270]).

A progress report emphasizing the following: (a) preparation of carrier-free Zr^{93}, (b) tracer studies with Zr^{89} and Zr^{93}, (c) intramuscular and intrapulmonary tracer studies with carrier-free Y^{88}, (d) intramuscular and intrapulmonary tracer studies with carrier-free Ce^{140}, (e) decontamination studies of radio-strontium, radio-yttrium, and radio-cerium.

MDDC - 1002 Summary of Metabolism of Carrier-Free Fission Products in the Rat, by J. G. Hamilton, 1 p., n.d., 5/14/47. (CH-775).

The following carrier-free fission products were studied to determine their effect upon the metabolism of the rat: Sr^{85}, Y^{86}, Zr^{89}, Cb^{93}, Ru^{105}, I^{131}, Xe^{127}, Ba^{133}, La^{140}, Ce^{140}, and a raw fission mixture. The results are presented in chart form.

MDDC - 1003 The Metabolism in the Mouse of 1,2,5,6-Dibenzanthracene Labeled in the G-Position with C^{14}, by C. Heidelberger and H. B. Jones, 4 p., May 2, 1947. (BP-83).

This document is an abstract.

Dibenzanthracene has been administered to mice as a colloid in isotonic glucose, and in fat solutions. The distribution of the radioactivity is summarized in a table.

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The most striking fact observed in the metabolism of dibenzanthracene injected intravenously as an aqueous colloid is the rapid elimination of large quantities in the feces.

In general it can be stated that the activity is not highly concentrated in any specific tissue of the body, but seems to be distributed fairly evenly throughout the internal organs. When the substance is given to animals bearing highly developed mammary carcinoma there is no appreciable concentration in the neoplasm. When the compound is administered intraperitoneally, either in oil or as an aqueous colloid, there is a higher concentration of activity in the intestines than in the intestinal contents. This is not observed with other methods of administration, and indicates the path of absorption to be across the exposed peritoneum of the gut. There is a low order of absorption when dibenzanthracene is given by stomach-tube in oil. Subcutaneous administration in oil indicated that at the end of six weeks 52% of the dibenzanthracene is retained near the site of injection. However, a small tumor which appeared at the site in that time interval showed that an appreciable part of the radioactive carbon in the tumor was no longer present in the form of dibenzanthracene, but 14% has been converted into an acidic form, and 21%, to a phenolic form. Thus 65% of the dibenzanthracene is unaltered. Aliquots of an extract of this tumor were assayed by both possible methods. The amount of dibenzanthracene calculated from the spectrographic data was twice the quantity obtained by direct radioactive assay, and this justifies previous observations that spectrographically interfering substances other than the carcinogen tend to give unreliable results.

MDDC - 1004 The Effect of Total Body X-Irradiation on a Pre-Existing Induced Anemia in Rabbits, Parts I and II, by L. O. Jacobson, E. K. Marks, E. Gaston, and E. Simmons, 49 p., March 1947. (CH-3428).

Part I. A regenerative anemia was produced in rabbits by the subcutaneous administration of phenylhydrazine hydrochloride. The hematological effects of 800 r total body X-irradiation on such anemic animals were compared to effects on normal untreated animals, on animals given phenylhydrazine and allowed to recover spontaneously, and on a group of animals which was given 800 r alone.

A characteristic initial rise and subsequent reduction in leucocytes and heterophils and an immediate precipitous fall in the lymphocyte values followed the administration of 800 r in the group in which a regenerative anemia had been produced with phenylhydrazine, as well as in normal control animals. The times for recovery of these elements to normal limits in the two groups were roughly comparable. An "abortive" rise in the leucocyte values of both these groups was noted between the 5th and 11th days after irradiation.

The group of animals that received X-irradiation alone developed an anemia with its maximum at 14 days and recovery by 23 days. The animals in which a regenerative anemia was produced by phenylhydrazine and which were irradiated at or near the point of maximum anemia developed no further anemia, values returning to roughly normal limits by 23 days. The erythrocyte and hemoglobin values of the group in which an anemia was produced by phenylhydrazine and which was allowed to recover spontaneously returned to normal limits within 14 days.

The reticulocyte values of animals that received phenylhydrazine alone, after reaching a maximum, fall spontaneously to normal values within 8 days. The reticulocyte value of similar groups of animals given 800 r at, or near, the time of the maximum reticulocyte response fell to a minimum of 1.6 per cent by six days, then quickly recovered to normal limits. The reticulocyte value of the control group of animals, which was given 800 r only, reached a minimum of less than 0.1 per cent by 3 days and

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recovery proceeded slowly. An "abortive" rise in the reticulocyte values of the experimental animals given 800 r occurred, largely comparable in time to that seen in lymphocyte and heterophil values.

The failure of 800 r to produce further anemia or to materially interfere with the recovery from the induced anemia in animals in which a regenerative anemia was produced with phenylhydrazine appears to be related to (1) a larger number of surviving erythroblasts and (2) a latency or delayed effect of the irradiation on these cells as a result of the phenylhydrazine stimulation of erythropoiesis.

A number of graphs are included.

Part II. A regenerative anemia was produced in rabbits by the withdrawal of 30 cc of blood by cardiac puncture on each of three successive days. The hematological effects of 800 r total body irradiation on such anemic animals were compared to effects on normal untreated animals, animals which were bled only and allowed to recover spontaneously, and a group of animals that was given 800 r alone.

After bleeding alone, significant reduction in the lymphocytes per cu mm of the peripheral blood occurs concomitantly with increased erythropoietic activity.

The classical pattern of lymphocytes and heterophil response to 800 r X-irradiation occurred in the group of normal animals and animals with a bleeding-induced anemia which were given 800 r.

A latent normochromic anemia reaching a maximum in 14 days occurred in normal rabbits after a dose of 800 r total body X-irradiation. The same dose effected no further anemia in rabbits in which an anemia had been previously induced by bleeding.

Recovery from the anemia proceeded at a slower rate in the latter groups due presumaoly to a combination of the effect of irradiation and the induced iron difficulty.

The explanation for the failure of 800 r X-irradiation to produce a further anemia or to drastically alter recovery in animals with an anemia induced by bleeding appears to be the survival of larger numbers of normal erythroblasts in erythropoietic tissue previously stimulated by the bleeding procedure as well as a delayed destruction of the erythroblasts in the "stimulated" animals.

A number of graphs are included.

MDDC - 1005 Metabolism of Fission Products—Radio Tellurium, by L. Jacobson, R. Overstreet, I. Chaikoff, and Associates, 19 p., October 1944. (CH-2258).

Methods of preparing Te^{127} and Te^{129} without carrier are described.

The results of oral and intramuscular experiments using tellurious tellurium (+4) and telluric tellurium (+6) are given.

Tellurium, whether administered either in the tellurious or telluric state, is absorbed by way of the digestive tract. It seems quite possible that in these experiments the +6 tellurium was not as readily taken up by way of the digestive tract and that its assimilation takes place by it first being converted to tellurious tellurium which is then absorbed.

The rates of elimination of absorbed tellurium in both valence states and by both oral and intramuscular administration are rapid and essentially comparable. The rates of excretion during the time intervals studied indicate an approximate half time of retention in the body of 16 days. This is substantially less than the half-lives of Te^{127} and Te^{129} which are 32 and 90 days, respectively. This observation places tellurium in the small list of the long life fission products whose rates of elimination are

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greater than their rates of radioactive decay. The other members of this group being ruthenium, xenon, and cesium. The principle organs of deposition for absorbed tellurium are blood, liver, and kidney. On the per gram basis the kidney tissue is from 2 to 5 times more active than any other of the tissues. In all of the intramuscular studies with tellurious and telluric tellurium the blood was more active per gram than the liver. The blood showed the highest per organ content of tellurium and it is of interest to note that these relative levels were maintained even up to the 32 day interval.

The small but constant retention of activity in the skeleton, which showed no significant change throughout the entire 32 day interval, together with the fact that the relative proportion of activity in the skeleton as compared to other tissues was somewhat lower in the oral experiments as compared to the corresponding intramuscular experiments suggests that there may have been from 2 to 5% of radioactive impurities in the tellurium preparations employed such as alkaline earths, rare earths, zirconium, and columbium. It does not appear that the tellurium shows any significant tendency to either deposition or retention by the skeleton.

MDDC-1006 The Uptake by Plants of Plutonium and Some Products of Nuclear Fission Adsorbed on Soil Colloids, by L. Jacobson and R. Overstreet, 9 p., August 15, 1945. (BP-82) (See also Soil Science Vol. 65 p. 129-134, February 1948).

The uptake of plutonium and the fission products Y, Ce, Sr, Te, and Zr + Cb by two species of plants, barley and dwarf pea, was examined. Studies were made using bentonite clay suspensions (barley) and a montmorillinite soil (dwarf pea). In all cases, the roots possess a marked ability to fix large proportions of the above elements even when trace amounts are initially adsorbed on clay particles. With the exception of Sr, the bulk of the activity remains in the roots. Sr is readily translocated to the tops.

On the basis of greenhouse experiments, it is concluded that soil activities of the order of 0.1 microcurie per gram in the region of contact with the roots will result in obvious injury to the plant. It is estimated that noticeable injury to the plant will occur at much lower levels of soil activity than 0.1 microcurie per gram.

MDDC-1007 Isotope Separation by Thermal Diffusion: Results of Comprehensive Calculations for the Cylindrical Case, by R. C. Jones, 19 p., May 2, 1941. (A-3491).

The results of extensive calculations for the cylindrical case are presented. The results were obtained by mechanical integration of the fundamental fourth-order differential equation by means of a differential analyser. By this means, restriction to the Maxwellian case was avoided. Comprehensive results for each of three different assumptions about the temperature dependence of the various gas coefficients are presented.

Part I is devoted to a statement of the analytical basis of the work, and Part II to the presentation of the numerical results.

MDDC - 1008 Some Excitation Functions of Alphas and Deuterons on Bi, by E. L. Kelly and E. Segrè, 1 p., April 29, 1947. (BP-80).

This paper is an abstract and is presented here in its entirety.

As a part of systematic investigation of excitation functions the absolute cross sections for the reactions $(\alpha,2n)$, $(\alpha,3n)$, (d,p), $(d,3n)$, (d,n) on Bi will be presented. The energy of the projectiles range up to 38 Mev for the α particles and up to 19 Mev for the deuterons. The thresholds for $(\alpha,2n)$, $(\alpha,3n)$, and $(d,3n)$ reactions are, respectively, 19 Mev, 29 Mev, and 12 Mev. The technique used is the usual one of bombarding stacked foils, but some improvements have been made on the definition of energy and measurement of current. Also the stopping power of Bi and other substances use has been redetermined with respect to Al. The relation of these curves to present theories on excitation functions and to other experimental data on the subject will also be discussed.

MDDC - 1009 Cu^{60} Radioactivity, by C. E. Leith, A. Bratenahl, and B. J. Moyer, 2 p., April 28, 1947. (BP-79) (See also MDDC-1085).

This is an abstract and is presented here in its entirety.

A β^+, γ activity of 24.5 minute half-life has been discovered and assigned to Cu^{60}. It has been produced by the reactions $Ni^{60}(p,n)$, $Ni^{60}(d,2n)$, and $Ni^{58}(\alpha,pn)$. The target materials were isotopically enriched by the calutron process. Protons of energies up to 15 Mev produced in the 37-inch frequency modulated cyclotron were used for the first reaction, 18 Mev deuterons and 36 Mev alpha-particles produced by the 60-inch cyclotron for the others.

The β^+ energy has been measured by absorption in Al as 1.8 Mev. The γ energy has been measured by absorption in lead, using Co^{60} γ absorption for calibration as 1.3 Mev.

Chemical separation of Cu from the Ni target after proton bombardment assigned the activity to Cu, and separation of target isotopes in a calutron immediately after bombardment showed that this isotope must be 60.

The proton threshold energy for the $Ni^{60}(p,n)Cu^{60}$ reaction lies between 4 and 5 Mev.

MDDC - 1010 Construction Features of a Circuit for Coincidence Measurements and Applications of the Circuit to Nuclear Problems, by C. D. Moak, 14 p., April 30, 1945. (CP-2806).

The development of a coincidence circuit is described and its uses and limitations are pointed out. The characteristics of the circuit are such that it may be set to any resolving time within the range 10^{-7} to 10^{-5} sec. The pulse duration in the circuit is less than 10^{-5} sec which is better than the resolving time of a counter tube. The input sensitivity is set to approximately 0.2 v so that the circuit has low sensitivity to external disturbances. In general testing the circuit did not lose any coincidences but certain precautions must be taken.

The circuit was used to determine the effective conversion coefficient for the γ rays from Au^{198} monitors activated in the pile and this is quoted at $7 \pm 1\%$. The conversion coefficient for Xe^{135} is quoted at about 10%.

An absorption curve for Compton-recoil electrons was obtained as an aid to γ ray energy measurements.

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A photograph of equipment and drawings of the circuit are included.

MDDC - 1011 Progress Report on Metabolism of Fission Products for Period Ending October 15, 1943, by R. Overstreet, L. Jacobson, H. Fisher, and K. Scott, 61 p., n.d., decl. 6/6/47. (CH-1049 [A-1441]).

Unseparated Fission Products

Unseparated fission products have been isolated from 18 pounds of neutron bombarded $UO_2(NO_3)_2 \cdot 6H_2O$ free from carrier and containing less than .03 micrograms of uranium per microcurie of activity. The final solution was assayed for its content of strontium, yttrium, praseodynium, zirconium, columbium, ruthenium, tellurium, cesium, barium, cerium, and UX_1. Tracer studies were done on a large group of rats which received the prepared solution by intramuscular, intraperitoneal, intrapulmonary, and oral routes of administration. The time intervals ranged from one to sixty-four days. The skeleton was the chief point of deposition for the absorbed radioactive mixture for all four routes of administration. Considerable and prolonged retention occurred in the lungs following intrapulmonary administration. From 3 to 5% was absorbed from the digestive tract.

Excretion was slow and the digestive tract was the chief channel of elimination.

Approximately 50% of the activity was excreted over the sixty-four day period following intraperitoneal and intramuscular injection.

Radio-Ruthenium ($Ru^{>105}$)

A carrier-free purified preparation of $Ru^{>105}$ (includes some other activities) has been isolated as a solution of $RuCl_4$ and tracer studies comparable to those for the fission mixture completed. $Ru^{>105}$ was found to be rather widely distributed throughout the body and the greatest degree of selective localization took place in the kidney which was considerably less than the degree of deposition and retention in bone for alkaline earths, rare earths, zirconium, columbium, and the fission mixture. Excretion was much more rapid than for the above listed substances and by sixty-four days in the intraperitoneal and intramuscular group less than 15% of the administered $Ru^{>105}$ was retained. Roughly two-fifths was eliminated by way of the kidneys and three-fifths by the digestive tract over the sixty-four day interval. No significant absorption took place by way of the digestive tract. Considerable retention of $Ru^{>105}$ took place in the lungs following intrapulmonary administration of the solution of $RuCl_4$. The distribution of absorbed fraction was similar to that noted in the intraperitoneal and intramuscular studies.

Neptunium ($Np^{238,239}$)

A mixture of Np^{238} and Np^{239}, free from radioactive contaminants and inert hold-back carriers, was isolated from a uranium metal target which had been bombarded by 16 Mev deuterons. Tracer studies, which included the intraperitoneal, intrapulmonary, and oral routes of administration, were carried out over a period of 8 days. The metabolic behavior of neptunium was found to resemble that of yttrium more closely than any of the other fission products studied thus far. The pulmonary retention following intrapulmonary administration was considerably less than for the rare earths, zirconium, columbine, ruthenium and fission mixture. Excretion was more rapid than that noted for the substances listed above with the exception of ruthenium. The amount eliminated during the 8 day period of the experiments was almost equally divided between digestive tract and kidneys. No significant absorption by way of the digestive tract took place.

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Radio-Autographic Studies

A large series of radio-autographs have been prepared from the lungs of the rats which had received the fission mixture, ruthenium, and neptunium by intrapulmonary administration. Photomicrographs of representative lung sections and their corresponding radio-autographs are included in the report. In the large series of radio-autographs prepared no significant deposition was noted in the bronchi, lymphoid tissue, and blood vessels. In all of the radio-autographs it was found that the radioactivity was distributed widely throughout the alveolar structure of the lungs. Frequently a tendency for the alveolar pattern of the sections to be duplicated on the radio-autograph was observed.

MDDC - 1012 Radiation Hazards of Bremsstrahlung, by H. M. Parker, 10 p., April 1944. (CH-1415[A-2279]).

This report is concerned with the hazards of bremsstrahlung arising from the beta radiation of pile produced activities (either fission products or induced radioactivities).

An attempt was made to reconcile the observed gamma radiation from a large tank of liquid with the theoretical estimate.

Solutions in the new separations process show a remarkably high ratio of β to γ activity. Special attention to the bremsstrahlung from a large mass of the material may be required.

Brief mention of bremsstrahlung from tanks in the Project literature refers to the radiation from the metal wall as the possible hazard.

Calculations are presented for the bremsstrahlung in lead and other metals, from tank walls and shipping containers of lead, aluminum, and glass. Recommendations are made as to the shielding to be provided for such containers.

MDDC - 1013 Cloud Chamber Study of the Particles in the Neutron Beam of the 184-Inch Cyclotron, by W. M. Powell, 1 p., April 28, 1947. (BP-77). (See also Physical Review, Vol. 72, p. 739, October 15, 1947).

This report is an abstract and is reproduced here in its entirety.

Recoil protons and disintergrating atoms in oxygen, nitrogen, helium, and carbon appear in cloud chamber photographs made in the neutron beam from 200 million electron volt deuterons. Frequently oxygen splits up into four doubly charged particles which may be alpha-particles. In some cases a large part of the energy of the neutron appears in one of the star particles.

An attempt has been made to discover the maximum energy of the neutrons in the neutron beam by observing the maximum energy of the recoil protons. Some of the protons show energies far in excess of the maximum of 120 Mev expected. Several have been found in the neighborhood of 200 Mev.

The cloud chamber is 16 inches in diameter with a magnetic field of 10,000 oersteds.

MDDC - 1014 Course in Nuclear Physics for Engineers, Radiation Laboratory, 143 p., January 15 to May 14, 1946.

This document contains a series of lectures given under the auspices of the Manhattan District. The lectures are listed as follows: particles, units, dynamics of particles, relativistic effects, by C. Helmholz; the cyclotron, by R. L. Thornton; summary of conversion factors and equations applying to magnetic accelerators, by W. M. Brobeck; the synchro-cyclotron, by E. M. McMillan; the synchrotron, by E. M. McMillan; D. C. magnet design, by W. M. Powell; the linear accelerator, by W. K. H. Panofsky; oscillators, by K. L. MacKenzie; Van de Graaf generator, by C. M. Turner; voltage, current, and phase relations on transmission lines, by K. L. MacKenzie; nuclear physics, by C. Helmholz; radioactivity, by C. Helmholz; the interaction of nuclear radiation with matter, by E. Segre; high vacuum practice, by W. M. Brobeck; particle counting and measurement, by C. Wiegand; cosmic rays and cloud chambers, by W. M. Powell; nuclear fission, by C. Helmholz.

MDDC - 1015 Polarography with Stationary Electrodes, by L. B. Rogers, 15 p., n.d., decl. 5/29/47.

Mixtures of ions which react rapidly with mercury usually cannot be analyzed polarographically with the dropping mercury electrode. However, these polarographic analyses appear to be feasible using solid electrodes made from noble metals. The general features of their behavior are covered.

The solid electrodes make possible the rapid examination of many organic and inorganic compounds in the anodic region as well as analyses in fused salts or in non-aqueous solvents (liquid ammonia) in low temperatures.

MDDC - 1016 Volume I. Experimental Techniques, Part I. Ionization Chamber and Counters, Section A, by B. Rossi and H. Staub, 223 p., October 28, 1946.

This document consists of chapters 8 - 12, which are titled as follows: Chapter 8, Behavior of Free Electrons and Ions in Gases; (a) general considerations, (b) the diffusion equation for ions and electrons in a gas, (c) mean free path—energy loss per collision, mixture of gases, (d) experimental data relative to free electrons, and (e) experimental data relative to positive and negative ions; Chapter 9 —Operation of Ionization Chambers with Constant Ionization; (a) general design of an ionization chamber, (b) constant ionization: diffusion and recombination neglected, and (c) constant ionization: diffusion and recombination not neglected; Chapter 10—Operation of Ionization Chambers with Variable Ionization; (a) general considerations, (b) ionization pulse, (c) influence on the pulse shape of the transient response of the amplifier: measure of pulse heights in ev, (d) continuously variable ionization, (e) parallel plate chamber, (f) cylindrical chamber, (g) edge effects, (h) testing of "fast" ionization chambers, (i) statistical fluctuations of the ionization current, (j) limits of validity of the theory, and (k) very rapidly rising ionization pulse; Chapter 11—Gas Multiplication; (a) general considerations, (b) experimental values of the gas multiplication for various gases, (c) pulse shape of proportional counters, (d) dependence of the pulse height on the distance of the track from the wire, (e) end effects: eccentricity of the wire, (f) spread in pulse height, and (g) multiple wire counter; and Chapter 12 —Beta-ray, γ-ray, and X-ray Detectors; (a) general considerations: discharge counters and integrating chambers, (b) yield of γ-ray detectors, (c) response of an integrating chamber, (d) cylindrical γ-ray ionization chamber, (e) multiple plate X-ray ionization chamber, (f) multiple plate γ-ray ionization chamber, (g) γ-ray ionization chamber with gas multiplication, (h) Geiger-Mueller counters, (i) mica window Geiger-Mueller counter, and (j) pulsed counters.

MDDC - 1017 Volume I. Experimental Techniques, Part II. Ionization Chambers and Counters, by B. Rossi and H. Staub, 163 p., October 28, 1948.

This document consists of chapters 13—16, which are titled as follows: Chapter 13—Alpha Particle Detectors; (a) alpha particle spectroscopy, (b) absolute counters, and (c) range measurements; Chapter 14—Detectors for Neutron Recoils; (a) introductory considerations, (b) general properties of hydrogen recoil chambers, (c) infinitely thin solid radiator: ion pulse chamber, or electron pulse chamber with grid, or proportional counter: no wall correction, (d) infinitely thin radiator: parallel plate, electron pulse chamber: no wall corrections, (e) thin radiator: parallel plate ion pulse chamber, electron pulse chamber with grid, or proportional counter: no wall correction, (f) thin radiator: parallel plate, electron pulse chamber: no wall correction, (g) thick radiator: parallel plate, ion pulse chamber, electron pulse chamber with grid, or proportional counter: no wall correction, (h) gas recoil chamber: no wall effects, (i) gas recoil, ion pulse chamber: computation of wall effects, (j) uses of recoil chambers, (k) high pressure, gas recoil, ion pulse chamber, (l) thin radiator, electron pulse, parallel plate chamber, (m) thin radiator electron pulse, parallel plate double chamber, (n) gas recoil, cylindrical chamber, (o) gas recoil proportional counter, (p) thick radiator, electron pulse, spherical chamber, (q) thin radiator, proportional counter, (r) integrating gas recoil chamber, and (s) coincidence proportional counter; Chapter 15—Detectors of (n,α) and (n,p) Reactions; (a) neutron spectroscopy using (n,α) or (n,p) reactions, (b) flux measurements, (c) boron chamber of high sensitivity, (d) BF_3 counter arrangement of high sensitivity, (e) flat response counters, (f) solid boron radiator chambers, and (g) absolute BF_3 detectors; and Chapter 16—Fission Detectors; (a) introduction, (b) parallel plate fission chamber, (c) small fission chamber, (d) flat fission chamber of high counting yield, (e) multiple plate fission chamber of high counting yield, (f) spiral fission chamber, and (g) integrating fission chambers.

MDDC - 1018 Metabolism of Plutonium in Rats, by K. Scott, et al., 27 p., October 15, 1944.

The results of detailed metabolic studies of plutonium following oral, intramuscular, intravenous, subcutaneous, and intrapulmonary administration are presented. Plutonium is not absorbed from the digestive tract. The skeleton is the chief organ of deposition for plutonium absorbed by the body following parenteral administration. The digestive tract is the principle channel of elimination and the degree of retention is very great. The rate of excretion is very slow and the half-period of retention of plutonium by the skeleton is estimated to exceed six months. No significant differences in the metabolic properties of plutonium absorbed by the body were observed for its three valence states. Considerable retention of plutonium by the lungs following intrapulmonary administration was observed and was found to be highest for the +4 state, less for +3 plutonium and least for +6 plutonium. A significant degree of absorption of plutonium from the lungs with subsequent deposition in the skeleton took place following the intrapulmonary administration of solutions of this element in its three valence states.

MDDC - 1019 Production of High Energy Neutrons by Stripping, by R. Serber, 2 p., April 28, 1947. (BP-75) (See MDDC-1238)

This document is an abstract and is reproduced in its entirety.

The narrow beams of high energy neutrons which result from the bombardment of nuclei by high energy deuterons are for the most part produced by a process in which the deuteron passes near the

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edge of the nucleus, the proton strikes the nucleus and is stripped off, while the neutron misses the nucleus and continues with almost the velocity of the incident deuteron. The cross section for this process is $\sigma = \frac{\pi}{2} RR_d$, where R is the nuclear radius, and $R_d = \sqrt{\frac{1}{2} M\epsilon_d} = 2.1 \times 10^{-13}$ cm is the deuteron radius (M is the proton mass, ϵ_d the binding energy of the deuteron). It varies from 0.1 barn for Be to 0.3 barn for U.

Since for the high deuteron velocities involved ($E_d \sim 190$ Mev) the time required for the stripping is short compared to the period of the deuteron, the neutron emerges from the collision with its momentum unchanged. The momentum is, of course, the resultant of the momentum due to the center of mass motion, $p_0 = \sqrt{ME_d}$, and the momentum of its motion within the deuteron. The probability distribution of the latter quantity can be found by Fourier analysis of the deuteron wave function, subject to the condition that the proton hits the nucleus and the neutron misses. Since the momenta of the neutron in the deuteron are for the most part smaller than $p_1 = \sqrt{M\epsilon_d}$, one sees that the emergent neutrons will have energies mostly in the band

$$(p_0 \pm p_1)^2 \quad / 2M \quad \tfrac{1}{2} E_d \left(1 \pm \sqrt{\frac{\epsilon_d}{E_d}}\right)^2$$

i.e.,

$$\tfrac{1}{2} E_d \pm 20 \text{ Mev.}$$

Similarly, most of the neutrons will come off at an angle to the direction of the deuteron beam less than $\theta = \frac{p_1}{p_0} = \sqrt{\frac{\epsilon_d}{E_d}} \sim 6°$. The angular spread of the neutron beam is expected to be somewhat wider for heavy nuclei than for light ones because of the deflection of the deuteron by the Coulomb field of the nucleus, and, to a lesser extent, because of multiple scattering in the target. A nearly linear increase in half-width with Z is predicted. The calculated curves of neutron intensity as a function of angle agree well with the measurements of Helmholz, McMillan, and Sewell in regard to shape, absolute width, and variation with atomic number.

In addition to the stripping process, high energy neutrons will be produced by direct nuclear encounters, and, for more distant impacts, by the dissociation of the deuteron by the Coulomb field of the nucleus. The total number of high energy neutrons produced by the former process should be comparable to the number produced by stripping, but since a considerably wider angular distribution is to be expected, these give only a small contribution to the narrow forward peak. The Coulomb break up has been considered by Oppenheimer and by Dancoff. The cross section is proportional to Z^2; it is unimportant compared to stripping for the light elements, while for the heaviest elements it would be expected to be half as large as the stripping cross section.

MDDC - 1020 Some Operating Phenomena Associated with the 184-Inch Cyclotron, by D. C. Sewell, L. Henrich, and J. Vale, 6 p., April 28, 1947. (BP-73). (See Physical Review, Vol. 72, p. 739, October 15, 1947.) (See MDDC-1092)

Two experiments have been performed on the 184-inch cyclotron which give a better understanding of the operation of a frequency modulated cyclotron.

First, to explain the disappearance of the beam at the radius of 82 inches several radioautographs of specially constructed probes were made. They show that the vertical height of the beam increases

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rapidly near the 82 inch radius. Where the value of n is approximately 0.2 ($n = -\frac{\rho}{H}\frac{dH}{\rho}$; ρ= radius, H = vertical component of the magnetic field). At this value of n, a coupling exists between the radical and vertical oscillations of the ions which appear to be strong enough to cause the energy of the radical oscillations to be converted into the energy of vertical oscillations, thus causing the beam to be intercepted by the dee at the 82-inch radius.

Second, a number of studies have been made using a synchroscope to observe the time structure of the beam current collected by the probe. The multiple pulse nature of each beam pulse seems to be explained by the radial oscillations of the beam. These oscillations are caused by the precession of the center of rotation of the ions about the true center of the system.

MDDC - 1021 Low Operating Potential Ion Counters, by J. A. Simpson, Jr., 1 p., n.d., decl. 5/22/47.

This document is an abstract and is reproduced here in its entirety.

The breakdown potential studies made by several investigators for parallel plates and coaxial electrodes in neon and argon gas mixtures have been used as the basis for experiments on permanent gas counters possessing low operating potentials. This lowering of breakdown potentials to only 10 - 20 per cent of their values for pure gases without changing pressures or geometry of electrodes can be principally ascribed to:

a. The unusually large values of α/E which occur when the neon metastable state lifetime is sufficiently reduced.
b. The anomalous increase of the ion multiplication region for inhomogeneous fields in proportional and Geiger counters.

Geiger counter threshold potentials as low as 112 volts for gas mixtures at 5 cm Hg pressure and up to about 200 volts for gas mixtures at 50 cm Hg pressure have been obtained which are entirely reproducible. The theory of operation of both proportional and Geiger counters and information regarding secondary processes at the cathode will be discussed.

When these counters are used with an electronic quenching circuit they have many desirable characteristics such as a flat operating region of 60 to 150 volts, the width being dependent on the pressure and gas mixture.

Portable instruments using these counters have been developed.

MDDC - 1022 Study of Plutonium Metabolism in Bone, by L. Van Middlesworth, 100 p., n.d., decl. 6/6/47. (BP-69).

A method is described whereby Pu^{239}, Sr^{89} and Y^{88} may all be distinguished in the same animal by differences in their radiations.

The chronic excretion of Pu^{239}, Sr^{89} and Y^{88} was followed for 11 weeks in rats injected simultaneously with these three elements. The very low rate of elimination of all three after the first month emphasizes the danger of chronic toxicity.

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Radioautographs of the tibia show radioactive strontium deposited throughout the bone with a heavy concentration in the region of new bone growth and active calcification beneath the epiphysis. Plutonium was shown to localize superficially in the endosteal and periosteal surfaces of the bone with no apparent concentration in the zone of bone growth and calcification.

Severe phosphate deficiency was found to diminish greatly the retention of radioactive strontium in the skeleton. The retention of plutonium at the site of intramuscular injection was reduced in the phosphate deficient rats, but the distribution of plutonium in the body was otherwise unchanged.

The maximum uptake of Pu^{239} and Y^{88} in the fracture callus occurred on the second or third day following fracture, before calcification had commenced. On the other hand, active Sr^{89} deposition did not begin until the 4-5 day, and reached a peak at 8-12 days when calcuification was most active.

Although plutonium and yttrium appear to deposit in uncalcified bone matrix, scurvy, which produces changes in connective tissue and osteoid matrix has no significant effect on the distribution of these elements, aside from a moderate decrease in the amount retained at the site of injection.

A period of three weeks on a protein free diet did not alter the distribution of plutonium in the rat, although it did decrease somewhat the retention at the injection site.

Following intramuscular injection, more Pu(IV) was retained at the injection site than Pu(VI), but the distribution in the body was otherwise similar.

Following intravenous injection, Pu(VI) disappears from the blood stream much more rapidly than does Pu(IV). There was also a much larger proportion of Pu(IV) deposited in the liver. These results indicate that the Pu(IV) may be in a colloidal state.

Methionine supplements resulted in a moderate decrease in the plutonium in the skeleton.

When large doses of cysteine were injected one hour prior to the intramuscular injection of Pu(VI), the absorption from the injection site and deposition in the skeleton was reduced. There was no effect when the Pu(VI) was administered intravenously.

MDDC - 1023 V. Pile Neutron Physics (2), by A. M. Weinberg, 21 p., n.d., decl. 6/3/47.

Calculations are presented for the distribution of neutrons in a medium traversed by channels.

A solution to the Boltzmann equation near a source of neutrons is derived.

A solution of the diffusion equation in various geometries by means of a Green's function or diffusion kernal is also proposed.

MDDC - 1024 Balanced Ionization Chamber for Differential Measurements of Gamma Rays, by C. Wiegand, 1 p., April 28, 1947. (BP-81).

This document is an abstract and is reproduced here in its entirety.

In connection with an investigation on the half-life of beryllium, it was important to have an apparatus that could measure small differences of strong gamma activities. Such an apparatus has been constructed. It consists of two equal ionization chambers connected to a single electrometer. The

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arrangement of the circuit is such that ionization current produced in one chamber tends to cancel the ionization current produced in the second chamber. The electrometer uses a conventional circuit employing an FP54 tube.

As a test of its performance and as another application, the half-life of Be^7 (52 days) and of 106 day Y were determined by measuring the variation of their activity against that of a radium standard. In a time of the order of 1/100 of the half-life it was possible to measure the half-life to an accuracy of $\pm$ 4 per cent using a sample equivalent in gamma activity to 50 μg radium.

It was found that the fluctuations observed in the actual balancing of the chambers was that to be expected on a statistical basis due to the discontinuous nature of radioactive emission.

MDDC - 1025 Body Tissue Ionization Due to Neutrons, by H. A. Wilson, 9 p., July 26, 1943. (CH-821)

A calculation is outlined for determining ionization due to slow neutrons. It appears that the number of γ rays per cm^2 per second at the surface of tissue is approximately equal to the number of slow neutrons entering the tissue per cm^2 per second.

The ionization in body tissue due to neutrons from an aperture in a pile shield is also calculated.

MDDC - 1026 Purification of Zirconium by Ion Exchange Columns, by J. A. Ayres, 11 p., n.d. decl. 6/30/47, (See Journal of the American Chemical Society, Vol. 69, p. 2879-2881, November 1947.)

A method has been developed for purification of zirconium by means of ion exchange columns. In this procedure the zirconium is present in the colloidal form and is not adsorbed by the resin while the impurities which are present as positive ions are adsorbed and thus removed. This method is rapid and easily adaptable to large scale procedures. Results of several experiments are given to show the efficiency of purification of zirconium from iron, titanium, beryllium, and lanthanum. A procedure is described for obtaining a purified solution of zirconium salt from a typical ore.

MDDC - 1027 The Dark Reductions of Photosynthesis, by A. Benson and M. Calvin, 6 p., May 27, 1947. (BC-57).

A comparison of the amounts and distributions of radioactive carbon dioxide fixed in the dark by the green alga, Chlorella pysenoidosa, with an without previous strong illumination has shown that a certain amount of reducing power is stored. The stored reducing power is apparently responsible for a five-fold increase in CO_2 fixation as well as an increase of radioactive sugar synthesis from 0.1% to 1.5%. Normally, succinic acid constitutes the major product of dark fixation while previously strongly illuminated algae form much less succinic acid and more of the related biological intermediates and neutral amino acids.

A mechanism for CO_2 reduction in plants is postulated to correlate the information.

MDDC - 1028 Half-Life Measurements on Dee, by A. Dodson, 4 p., March 11, 1947.

Experiments were performed to determine the half-life of the active portion of the dee and was found to be approximately seven hours.

The results are plotted on graphs.

MDDC - 1029 Note on Angular Distributions in Nuclear Reactions, by E. Eisner and R. G. Sachs, 6 p., n.d., decl. 7/2/47. (See Physical Review, Vol. 72, p. 680-681, October 15, 1947.)

A proof is given of the physically plausible theorem that in a nuclear reaction produced with an unpolarized beam of given orbital angular momentum incident on an unpolarized target, the angular distribution of the outgoing intensity cannot be more complicated than that of the incoming intensity.

MDDC - 1030 Vapor Pressure of Beryllium Oxide, by N. D. Erway and R. L. Seifert, 16 p., September 1946. (CF-3626).

The vapor pressure of beryllium oxide has been measured in the temperature range 1950°C to 2150°C by a modified Knudsen effusion method. The vapor pressure in this temperature range is given by equation

$$\log_{10} P_{mm} = 18.32 - \frac{34,230}{T} - 2 \log_{10} T$$

The boiling point is estimated to be about 4300 C with a molar entropy of vaporization at the boiling point of about 26 cal/deg.

A diagram of the apparatus is included and a bibliography is given.

MDDC - 1031 Analysis of Thorium-Chromium Mixtures, by R. E. Ewing and C. V. Banks, 10 p., n.d., decl. 7/2/47. (See Analytical Chemistry Vol. 20 p. 233-235, March 1948)

A method especially suitable for the analysis of thorium-chromium mixtures is presented which involves the perchloric acid oxidation of chromium in the presence of thorium, followed by titration with ferrous sulfate and tetrasulfactoceric acid. The thorium is precipitated as the oxalate and determined gravimetrically after removal of the chromium as chromyl chloride.

A drawing of the apparatus is included.

MDDC - 1032 Pulsed Deflector for 184-Inch Frequency Modulated Cyclotron, by G. M. Farley, 19 p., May 9, 1947. (BP-87).

This report describes systems for applying a 150 to 300 kv impulse to obtain electrostatic deflection. Two general methods are indicated. In one case, impulses are applied to high voltage cables by means of a triggered spark gap. In the other cases the voltage is developed in a pulse transformer when

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capacitors are discharged in series with the primary windings. The discharge is controlled by hydrogen thyratron tubes. The rise time of the voltage is approximately 0.1 microseconds and the pulse duration is about 0.2 microseconds. Both systems have worked on a trial basis, though the pulse transformer is favored.

Diagrams are included.

MDDC - 1033 A Laboratory Oscilloscope, by V. Fitch and E. W. Titterton, 30 p., February 26, 1947. (See also Review of Scientific Instruments, Vol. 18, p. 821-830, November 1947.)

The laboratory oscilloscope is designed primarily for use in the nuclear physics laboratory but is a versatile instrument well suited to general circuit research. It contains a sweep generator with writing speeds ranging from 8 inches per microsecond to 1 inch per millisecond. The sweep is initiated by a voltage amplitude discriminator which may be triggered by: (a) an internal trigger generator operating at variable repetition rates, (b) a jitter-free delayable trigger which may be generated at any time from minus 2 to plus 400 microseconds with respect to a fixed trigger from the master generator, (c) from any arbitrary signal greater than 5 volts, (d) any input to the signal amplifier larger than 0.2 volts. A high fidelity delay line is incorporated in the amplifier circuit so that the sweep may be initiated by the input signal to the amplifier before the signal appears on the scope plates. A 1 volt input to the amplifier will give a $1\frac{1}{2}$ inch screen deflection with a minimum rise time of 0.15 microseconds. The trigger generator, which starts the delay circuits, may be triggered externally by pulses of 15 volts amplitude or more. Sufficient voltage is applied to the type 5CP11 scope tube to permit photography of transients with writing speeds of 3 inches per microsecond using a camera with a F2 lens opening and Ansco Fluorapid film or Eastman 103-0 plates.

MDDC - 1034 Cosmic-Ray Induced Fission, by D. K. Froman, L. Rosen, and B. B. Rossi, 3 p., n.d., decl. 6/20/47. (LADC-415).

Fission produced by cosmic-ray neutrons is like any other kind of fission. Fission fragments can be detected by the well-known photographic method. Special Eastman fission plates show tracks of fission fragments without troublesome background. The first slide shows microphotographs of tracks produced by the fission of U-235 by cosmic-ray neutrons. A case of a collision of a fission fragment with a heavy nucleus in the emulsion, probably silver, is shown.

On examining a total of some thirty thousand fields of view on photographic plates placed in contact with foils of U-235, U-238 and thorium, fission has been found to occur in each case when the plates were exposed to the cosmic radiation at an altitude of 30,000 ft. In the case of U-235, the fission rate is increased very appreciably by surrounding the foil with two inches of paraffin. This is to be expected from the slowing-down properties of paraffin for neutrons and the increased fission cross-section of U-235 for slow neutrons. Since both U-238 and thorium exhibit fission, it is clear that there are at least a few neutrons of energy above the fission thresholds of these elements.

Using the fission data from the photographic plates, and the ratios of the counting rates of B-10 counters shielded in three different ways, a spectrum has been deduced for the cosmic-ray neutrons at 30,000

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feet. This spectrum does not change much with altitude up to 30,000 ft, since the ratios of the counts remain constant from 10,000 to 30,000 feet. Slide number two shows the spectrum obtained in 1947.

The total density of neutrons of all energies at 30,000 feet comes out to be about 0.8 per cubic meter.

MDDC - 1035 Reflection Spectra of Neutrons from Crystals, by M. Ginsburg, M. L. Goldberger, and F. Seitz, 17 p., February 8, 1945. (CP-2708).

The recent experiments at Argonne and Clinton on the reflection spectra from crystals are discussed. A theoretical treatment based on reports, CP-2409 and CP-2512, is given.

The reflected intensity from a crystallographic plane characterized by the Miller indices (h_1,h_2,h_3) for a given order, n, is given by

$$R_n = C|a_n| nK_1 \csc^3\nu \; e^{-\alpha n^2 \csc^2 \nu}$$

where

$$K_1 = \frac{2\pi}{d_h}, \quad \alpha_n^2 = \frac{\hbar^2 \left(\frac{2\pi}{d_h}\right)^2}{8mk_oT} n^2,$$

$$a_n = \sum_j \sqrt{\sigma_s^j(b)} \; e^{i\,2\pi n(h_1x_j + h_2y_j + h_3z_j)}$$

where C is an arbitrary constant, d_h is the interplanar spacing, $\hbar$ is Dirac's constant, m is the neutron mass, K_o is Boltzmann's constant, T is the average neutron temperature, $\sigma_{sj}(b)$ is the scattering cross section of the j^{th} atom in barns, and (x_j, y_j, x_j) are the coordinates of the j^{th} atom in the unit cell.

The question of the ambiguity of algebraic sign appearing in the definition of a_n is discussed and it is shown how by combining the results of reflection spectra and total reflection data this ambiguity may be resolved. This problem is discussed in detail for $CaCO_3$.

The effect of nuclear spin in producing incoherent scattering is considered. The good agreement between the theoretical and experimental curves in the cases of LiF and NaCl indicates that this effect is negligible since the derivation of the expression for R_n neglects spin effects.

On the basis of the reflection spectrum from calcite obtained with radiation from a graphite thermal column an energy distribution for the neutron beam has been proposed. It is believed that the energy distribution is not exactly Maxwellian, but is distorted on the low energy side of the maximum. The experimental results could be explained if it is assumed that there is an excess of very cold neutrons and a deficit in those having energies somewhat less than the most probable.

The energy distribution in the neutron beam coming directly from the pile is Maxwellian over the entire range with the exception of a high energy tail. This is explained by the fact that the high energy distribution is given by dE/E where E is the neutron energy.

An experimental method for determining the scattering cross sections of certain elements by the use of reflection spectra data is proposed. This method is feasible whenever the a_n's for different planes involve the scattering cross sections in independent ways.

MDDC - 1036 The Diffraction of Neutrons by Crystals. Part II, by M. L. Goldberger and F. Seitz, 38 p., December 1, 1944. (CP-2489).

The background scattering caused by inelastic collisions when a polychromatic beam of slow neutrons is reflected from a crystal is discussed. This background is of interest in the construction of a neutron monochrometer based on Laue-Bragg scattering since it determines the purity of the spectrum which passes through the exit slits that are oriented to receive a specularly reflected beam. The treatment is based on Weinstock's analysis of the inelastic scattering cross section of a small crystal and deals with the approximation in which the neutron gains or loses only a single vibrational quantum in a collision with the lattice.

It is shown that the contamination at the spectrum is strongly dependent upon the ratio v/c of the neutron velocity to the velocity of the sonic vibrations of the crystal. If this ratio is small compared to unity, the inelastically scattered radiation reaching the exit slits is small in intensity and does not differ appreciably from the radiation that is reflected elastically. The more precise condition for this state of affairs is that the quantity

$$\frac{c}{v} \tan\theta$$

be less than unity. Here θ is the Bragg angle for neutrons having the velocity v. Moreover, in this case the neutrons scattered inelastically from a given monochromatic incident beam are distributed through a very small solid angle.

When v is greater than c, the inelastically scattered radiation for a given monochromatic incident beam ranges over a large solid angle. In this case a wide range of wave lengths reaches the exit slits when the incident beam is polychromatic and there is a much larger background contamination than when c is small compared to v.

The ratio of the inelastically scattered radiation to the specularly reflected radiation reaching the exit slit system for a crystal containing one atom per unit cell is in both cases given by an equation of the form

$$R = \alpha\sqrt{\sigma_s}\ \frac{m}{M}\ \left(\frac{v_t}{c}\right)^2\ \frac{n^2}{d^2}\ \beta_h t_o\ \frac{\omega}{\Omega} \qquad (1)$$

Here α is a factor near unity for typical cases, σ_s is the atomic scattering cross section, m/M is the ratio of the neutron mass to the atomic mass, v_t is the velocity of neutrons having an energy $2k_oT$, where K_o is Boltzmann's constant and T is the crystal temperature in degrees Kelvin (e.g., v_t is 2200 meters per sec when T is room temperature), d is the spacing between reflecting planes, n is the integer giving the order of the Bragg reflection, t_o is the thickness of the crystal, β_h is the angular aperture of the exit slits in the plane containing the incident and reflected beam when viewed from the crystal and ω/Ω is the ratio of the rocking angle for high reflectivity from a perfect crystal to the angular spread of orientation of mosaic blocks. ω/Ω may be as large as 1/50. In the case of a crystal containing more than one atom per unit cell $\sqrt{\sigma_s}/M$ should be replaced by

$$\left|\sum_j \pm\sqrt{\frac{\sigma_s^j}{M^j}}\ e^{i\underline{K}\cdot\underline{r}_j}\right|^2 \Big/ \left|\sum_j \pm\sqrt{\sigma_s^j}\ e^{i\underline{K}\cdot\underline{r}_j}\right| \qquad (2)$$

where σ_s^j is the scattering cross section for the jth atom in the unit cell, M^j is its mass, $\underline{r}_j$ is its position vector and $\underline{K}$ is the reciprocal lattice vector associated with the crystallographic plane from which the reflection takes place. The numerator of (2) is essentially a structure factor for inelastic scattering, whereas the denominator is the structure factor for elastic or Laue-Bragg scattering. The fact that these two quantities are different in form because of the presence of the atomic masses in the first shows that inelastic scattering may be expected from planes for which there is no elastic scattering

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because of accidental destructive interference, and vice versa.

It is recommended that the crystal used in a spectrometer be a crystal such as MgO which posses a large value at c (about 8000 meters per sec) and a small lattice and constant. The crystal should also be chosen so that Ω is of the order of a minute of arc.

The inelastic scattering which takes place because of interaction with the optical branches of the lattice vibrations is discussed and is shown to be small compared with that scattered by the acoustical branch provided the soild angle subtended by the detector is small.

MDDC - 1037 Properties of Crystals in Neutron Diffraction Experiments, by M. Goldberger and M. Ginsburg, 16 p., December 15, 1944. (CP-2512).

The energy distribution in a beam of neutrons emanating from a thermal column is discussed. Using this distribution, expressions are derived for average values of the index of refractions, the extinction coefficient, depth of penetration, critical angle and reflectivity. Curves of reflectivity as a function of index of refraction and glancing angle, as well as curves of the average reflectivity as a function of these same quantities are given.

MDDC - 1038 A Method for Handling and Purifying UF_6 in Glass Vessels by Means of Alkali Fluoride Getters, by A. V. Grosse, 4 p., September 1945. (XAC-S-1690).

A new and efficient method for handling and purifying UF_6 in glass vessels became available when it was discovered that alkali fluorides, in particular potassium and sodium fluorides, act as very efficient getters of impurities in UF_6.

Comparative tests showed that, whereas without KF or NaF glass is rapidly attacked, it stays clear for a year or more in the presence of these fluoride getters.

MDDC - 1039 Note on the Separation of Hydrogen Fluoride from Uranium Hexafluoride, by A. V. Grosse, 4 p., September 1945. (XAC-S-1689).

Methods of separating hydrogen fluoride from uranium hexafluoride are proposed. The first method proposes decantating or filtering the products of Ruff's reaction. However, a better separation can be effected by fractional distillation at low pressures.

MDDC - 1040 Note on the Use of Silica-Free Glasses for Handling Anhydrous Hydrogen Fluoride and Uranium Hexafluoride, by A. V. Grosse, 5 p., September 1945. (XAC-S-1694).

Using silica-free aluminum phosphate glasses it was possible to conduct experiments which showed conclusively that uranium hexafluoride has a very small solubility in anhydrous hydrogen fluoride. This could be checked by observing a crystal of UF_6 sink in an excess of boiling HF and dissolve to only a small extent.

MDDC - 1041 UF_5, A New Fluoride of Uranium, by A. V. Grosse, 4 p., April 1944. (XAC-S-1643).

The discovery of uranium pentafluoride, UF_5, is reviewed and a method of preparation is presented.

When UF_4 is heated with excess liquid UF_6 at 95-100° for periods of 20-100 hours, the new compound UF_5 is formed. It is a greyish-white solid, violently decomposed by water into UF_4, UO_2F_2 and HF.

MDDC - 1042 A New Naturally Occurring Lanthanum Isotope at Mass 138, by M. G. Inghram, R. J. Hayden, and D. C. Hess, Jr., 1 p., April 21, 1947. (ANL-AJD-168) (See also Physical Review Vol 72, p. 349 August 15, 1947)

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Lanthanum was studied with a Nier-type mass spectrometer, using a thermal ionization source coated with the oxide and a vibrating reed electrometer. It was known from previous experiments that the heated oxide emits primarily oxide ions at mass 155. Peaks at masses 154, 155, 156, and 157 were observed. The 155, 156, and 157 peaks were present in relative abundances characteristic of $La^{139}O^{16}$, $La^{139}O^{17}$, and $La^{139}O^{18}$. The peak at 154 was unexpected, but was always present to the same relative amount in three different lanthanum samples. The possibilities that this new peak might be due to $Ce^{138}O^{16}$, $Ba^{138}C^{16}$, Sm^{154} or Gd^{154} were ruled out because these elements would also have given other lines. The 154 line is attributed to an isotope of lanthanum, La^{138}, which is present to 0.089 ± .001%. This La^{138} isotope has an odd number of neutrons and an odd number of protons, similar to the K^{40} and Lu^{176} isotopes which are naturally radioactive. Because of this fact an investigation of the activity of normal lanthanum was made. Beta-ray emission of approximately 250 Kev was found in all samples. Assuming the activity to be due to the disintegration of La^{138}, a measurement of the specific activity gave a value for the half-life of this isotope of approximately 2×10^{10} years. A more complete description of this investigation will be published in the near future.

MDDC - 1043 The Radiation from 60 Day Ir^{192} and 27 Day Pa^{233}, by P. W. Levy, 3 p., n.d., decl. 6/12/47. (See also Physical Review, Vol. 72, p. 352, August 15, 1947.)

The 180° beta-ray spectrometer, which was used in the determination of the maximum energy of the beta-ray spectrum of C^{14}, has been used to investigate the conversion electron and beta-ray spectrum of 27 Day Pa^{233}. This spectrometer, and an additional photographically recording spectrograph, were employed to analyse the spectrum of the 60 Day Ir^{192} activity.

The data on the conversion electrons from Pa^{233} are summarized.

The beta-ray and conversion electron spectrum of the 60 day Ir^{192} activity consists of a large number of conversion lines superimposed on what appears to be a simple continuous spectrum. The maximum energy of the spectrum, determined from Kurie plot constructed from data taken with the 180° spectrometer, is .67 Mev. This value would be accurate to 2% if the presence of the conversion lines near the high energy end of the spectrum did not introduce the possibility of a larger error. Because of these lines the shape of the spectrum is difficult to ascertain. Consequently, there is the possibility that the spectrum consists of several components, but a theoretical analysis based on its shape cannot be made.

The conversion lines were studied with the photographic spectrograph and the results are summarized. These results are in agreement with, but are more accurate than, those obtained with the 180° counter spectrometer. The accuracy of the gamma ray energies for both the Pa^{233} and Ir^{192} is approximately 2%. The energy differences of the observed lines agree best with the differences between the electronic levels of Pt, and therefore, it was assumed that all of the conversions take place in the Pt atom formed by beta-decay.

MDDC - 1044 Use of a Zinc Spiral in the Titrimetric Determination of Uranium, by J. M. McClure and C. V. Banks, 4 p., n.d., decl. 6/17/47.

A zinc spiral is used to reduce uranium solutions in order to eliminate the transfer of solutions involved in the use of an amalgamated zinc Jones reductor. The results obtained were excellent.

A recommended procedure is given.

MDDC - 1045 R. F. System for Frequency Modulated Cyclotron, by K. R. MacKenzie and V. B. Waithman, 21 p., August 1, 1946. (BP-25). (See Review of Scientific Instruments, Vol. 18, p. 900-907, December 1947.)

A grounded grid oscillator and a single dee resonant system for use with a frequency modulated cyclotron are described. 7.5 Mev deuterons have been accelerated with dee voltages up to 15 kv and a frequency range from 9.5 to 12 megacycles. 15 Mev protons have been accelerated with voltages up to 11 kv and a frequency range from 19 to 24 megacycles. Coupling constants, phase correction, amplitude modulation and discharge phenomena are discussed.

Photographs and diagrams are included.

MDDC - 1046 Energy and Half-Life of the Be^{10} Radioactivity, by E. M. McMillan, 8 p., May 16, 1947. (BP-88). (See also Physical Review, Vol. 72, p. 591-593, October 1, 1947.)

The half-life and upper limit beta ray energy of Be^{10} have been measured, using a sample prepared from a strongly deuteron-bombarded Be target. The upper limit energy, from the inspection end point of the absorption curve, is 560 ± 10 kev. The half-life, from the specific activity (56 disintegrations per second per mg Be) and the directly measured isotopic abundance (one part in 18,600) is $(2.5 \pm 0.5) \times 10^6$ years, making this the longest-lived artificial activity as yet observed. A rough excitation curve and good evidence for the absence of a gamma ray were also obtained.

MDDC - 1047 Synthesis of Chloracetic Acid, Iodoacetic Acid and Glycine, Labeled with C^{14} in the Carboxyl Group, by R. Ostwald, 7 p., May 5, 1947. (BC-56). (See Journal of Biological Chemistry, Vol. 173, p. 207-209, March 1948.)

Carboxyl-labeled chloracetic acid has been prepared by passing a stream of dry chlorine through a mixture of anhydrous carboxyl-labeled acetic acid, using a mixture of iodine, phosphorus and phosphorus pentoxide as catalyst. The carboxyl-labeled, anhydrous acetic acid was liberated from carboxyl-labeled sodium acetate by heating the dry salt in a stream of dry gaseous chloride and distilling the liberated acetic acid.

Carboxyl-labeled iodoacetic acid was prepared from carboxyl-labeled chloracetic acid by allowing a mixture of chloracetic acid and sodium iodide in dry acetone to stand for twenty hours at room temperature. The sodium chloride was filtered, and the sodium iodoacetate was precipitated by adjusting the solution to a pH of 6.8 with 40% sodium hydroxide.

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Carboxyl-labeled glycine was prepared by heating a mixture of carboxyl-labeled chloracetic acid, ammonia, and ammonium carbonate in the proportion of 1:15:5 for six hours to 60° and precipitating the glycine by addition of absolute methanol, after the solution had been concentrated.

MDDC - 1048 Fission of Bismuth, Lead, Thallium, Platinum, and Tantalum with High Energy Particles, by L. Perlman, R. H. Goeckermann, D. H. Templeton, and J. J. Howland, 4 p., May 16, 1947. (BC-58). (See Physical Review, Vol. 72, p. 352, August 15, 1947.)

Fission has been observed by chemical separation of fission products following the irradiation of bismuth, lead, thallium, and platinum with 400 Mev helium ions and of bismuth, lead, and thallium with 200 Mev deuterons. Fission of bismuth has been observed with deuterons as low as 50 Mev although the fission yield falls off in decreasing the energy of the deuterons from 200 Mev to 50 Mev. The fission yield seems to drop in decreasing atomic number from bismuth to tantalum. Marked asymmetry in the distribution in the fission products is not noted in these fission reactions. In some cases light isotopes of a given atomic number were noted.

MDDC - 1049 High Energy Photo-Disintegration of the Deuteron, by M. E. Rose and G. Goertzel, 23 p., n.d., decl. 6/2/47. (See Physical Review, Vol. 72, p. 749-757, November 1, 1947.)

The disintegration of the deuteron by γ-rays in the range 50 - 250 Mev has been investigated. The lower energy limit is imposed by the neglect of nuclear forces between the neutron and proton after absorption of the photon. Moreover, the effects of retardation and of multipole radiation higher than dipole, the investigation of which constitutes one of the primary purposes of the present work, become apparent only above 50 Mev. The upper limit is imposed by the assumption that the nuclear particles can be treated non-relativistically. It is shown that at the high radiation energies considered it is essential to take into account the range of the nuclear forces in the ground state and that this is the case because of the importance of interference effects (short De Broglie wave length of the nucleons) which depend very strongly on the "size" of the deuteron. The cross section at 50 Mev is 37μ b (37×10^{-30} cm^2) and decreases with γ-ray energy up to 150 Mev like $(n\omega)^{-n}$ where n lies between 4 and 5. Beyond 150 Mev the cross section decreases less rapidly due to a more favorable phase relation between outgoing waves from different parts of the deuteron. The general features of the cross section and of the angular distribution of the particles can be understood in terms of interference; the most important effect of the interference is to strongly favor small momentum for the recoil particle (proton in the case of charge coupling and both proton and neutron in the case of spin coupling). The error due to neglect of nuclear forces in the final state is estimated by a consideration of electric dipole transitions, to be less than 30 per cent in the worst case (low energy photons). The effects of retardation and higher multipoles are calculated explicitly and it is shown that these effects are small at 50 Mev and important at 100 Mev. It is also shown that the effect of non-central forces between the nucleons in the ground state introduces negligible error.

MDDC - 1050 Range of Ra-α-Be Neutrons in Water, by J. H. Rush, 11 p., June 30, 1945. (See Physical Review, Vol. 73, p. 271-273, February 15, 1948.)

Radial Distributions of Ra-α-Be neutrons about an approximate point source in water were determined by means of indium foil activation. Values for migration area derived from the data are: For all activating neutrons, 54.7 cm^2; for indium resonance neutrons, 45.4 cm^2.

MDDC - 1051 Vertical D. C. Electrostatic Deflector, by D. Sewell, 4 p., February 18, 1947.

It was found from previous experiments that the beam was rapidly spreading vertically at approximately the 81" radius. It was thought that if a vertical deflector was placed below the median plane at this 81" radius, the beam could then expand into the deflecting channel. Once in the deflecting channel it could then be deflected rapidly into a region in which a magnetic shield (or deflector) could be used to bring the beam out of the cyclotron.

Approximately 60 kv could be held on the high voltage electrode of this deflector.

On one occasion it looked as if an ionization chamber mounted on the probe was detecting a small deflection of the beam. However, this could not be verified on subsequent runs.

The best detection of the beam deflection was made by mounting X-ray film on the probe and exposing it to both the undeflected and deflected beam.

There was considerable sparking between the hv electrode and the .002" copper foil. The copper foil was warped badly when the deflector was removed; this had apparently been caused by the local heating from the sparking. The 0.002" copper foil supported in this manner is not suitable for this job.

The copper foil was very radioactive after a short run.

MDDC - 1052 A Combined Shutter and Projection Device for the Alignment of Electrodes in Spectrographic Analysis, by A. L. Smith and V. A. Fassel, 4 p., n.d., decl. 6/12/47.

For careful work in spectrographic analysis the electrodes must be accurately positioned before the exposure starts. Alignment is usually made by means of a movable lamp, an auxiliary lens, and a previously marked screen. The device described uses a lamp permanently fixed at one side and a mirror which is moved in and out of the optical path by a double solenoid arrangement. The solenoids are activated by conveniently placed push buttons.

MDDC - 1053 Artificial Radioactive Isotopes of Bismuth and Lead, by D. H. Templeton, J. J. Howland, and I. Perlman, 19 p., n.d., decl. 6/30/47. (BC-47). (See Physical Review, Vol. 73, p. 766-771, November 1, 1947.)

Seven lead and bismuth activities have been identified from the bombardment of thallium, lead and bismuth with cyclotron deuterons and helium ions, and of lead and bismuth with pile neutrons.

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Isotopes	Half-life	Decay	Radiations observed	Produced by
Bi^{204}	12 hours	K, γ	e^-, X-rays, γ	Tl(α,3n) Pb^{204}(d,2n)
Bi^{206}	6.4 days	K, γ	e^-, X-rays, γ	Po^{206} decay Tl(α,3n) Pb^{206}(d,2n) Pb^{207}(d,3n)
Bi^{209}* or Bi^{208}	long-lived	?	e^-, γ	Bi(n, n) or Bi(n,2n)
Bi^{210}	5.0 days	β^-	β^-	Bi(n,γ) Bi(d,p) Pb^{208}(α,pn)
Pb^{203}	52 hours	K, γ	e^-, γ	Tl(d,2n) Pb^{204}(n,2n)
Pb^{204}*	68 minutes	I. T.	e^-, γ	Bi^{204} decay Tl(d,3n)
Pb^{209}	3.3 hours	β^-	β^-	Pb(d,p) Pb(n,γ)

No activity has been found which can be attributed to Bi^{203}, Bi^{205}, Bi^{207}, Pb^{202}, or Pb^{205}, although all of these isotopes must have been produced.

MDDC - 1054 Uranium Poisoning, by S. Wexler and G. E. Boyd, 5 p., July 9, 1942. (CC-16).

Poisoning from uranium may come about either through inhalation of uranium oxide dust (U_3O_8, UO_2, or UO_3) or through contact with the soluble salts.

The pathological manifestation of uranium poisoning is nephritis, an inflammation of the kidney. The intesity of the anatomical and functional lesion is the result of the accumulation of the metal in the organ as a result of attempts at excretion.

Protection of the body against uranium involves protection of the hands and care to avoid inhalation or ingestion. In the synthesis of uranyl nitrate, rubber gloves are recommended. Protection against ingestion depends solely upon the worker; care must be exercised to prevent the taking of any uranium by mouth during such operations as pipetting.

A bibliography is included.

MDDC - 1055 Szilard-Chambers Reactions. I. The Principles of the Enrichment, by A. W. Adamson and R. R. Williams, Jr., 11 p., n.d., decl. 6/20/47. (ANL-HDY-182).

Two factors influencing the success of a Szilard-Chalmers enrichment reaction are discussed and rendered into mathematical form. The first of these, non-activating decomposition of the bombarded form, produces stable atoms which separate with the active form, thus lowering the specific activity obtainable. A first order rate law is assumed for this reaction and an equation derived which describes the enrichment as a function of time and intensity of bombardment.

The second effect considered is the loss of separable activity due to some radiation-induced reaction. This lowers the fraction of activity which is separable by returning the active atoms to some inseparable form. Again a first order rate law is assumed and an equation derived which describes the enrichment as a function of time and intensity of bombardment.

MDDC - 1056 Radiation Chemistry of Aqueous Solutions, by A. O. Allen, 21 p., n.d., decl. 6/23/47. (See Journal of Physical and Colloid Chemistry Vol. 52, p 479-490, March 1948)

Radiation chemistry of aqueous solutions is discussed under the following headings: back reaction in the decomposition of water; effect of solutes on the steady state; probable chain characters of the back reaction; the proportion of radicals available for reaction with solutes; oxidation and reduction of solutes and decomposition of water in solutions; rates of hydrogen evolution; and effects of size of gas volume.

MDDC - 1057 Portable Probe Type Ionization Meter, by G. R. Carlson, 6 p., December 10, 1945. (CP-3385).

A probe type portable radiation meter, "Betty Snoops", which can be used for the localization of small sources and beams of gamma and beta radiation is described. One application is the localization of the gamma and beta activity in a chemical separation or preparation carried out in a glass vacuum system.

Procedure for the calibration of the instrument is given.

A circuit diagram and photograph of the instrument are included.

MDDC - 1058 High Temperature Equilibria in Metal: Metal Halide Systems, by D. Cubicciotti, 61 p., June 1946.

A thesis has been submitted with detailed discussion under the following headings: description of former work; experimental work; phase diagrams (method, results, discussion); solubility of metals in salts with different cations; distribution of calcium between magnesium and calcium chloride; electrical conductivity of the calcium-calcium chloride system.

A bibliography of 46 references is included.

MDDC - 1059 Instrument Work in an Atomic Energy Laboratory, by H. U. Fisher, 40 p., n.d., decl. 6/17/47.

A general discussion of alpha, beta, gamma, and neutron counters which are used at Clinton Laboratories, Oak Ridge, Tennessee. Methods of building the instruments, their use and repair are also discussed generally. Nineteen photographs are included.

This paper has been delivered as a lecture.

MDDC - 1060 Summary of Iodine Physiology and Metabolic Studies Using Radioactive Isotopes of Iodine, by J. G. Hamilton, 6 p., October 18, 1944. (CH-2257).

A study of the absorption and excretion in normal human subjects indicates that this element is rapidly absorbed and rapidly eliminated. When a labeled dose of 14 milligrams is given to normal human adult subjects the iodine is almost exclusively excreted by way of the kidneys at an exponential rate, the half time being approximately 18 hours. The uptake by the thyroid under these conditions for normal adult subjects averages 4%. With the exception of the rat, the average uptake by the thyroid gland of radioiodine without inert carrier at the end of 24 hours was approximately 20%. In the case of the rat the uptake was considerably greater and frequent levels in excess of 65% were encountered. Comparable studies with human subjects has given a value of 20% uptake for normal adults when iodine without carrier was used.

At the end of 26 hours in both the thyroid and in the blood plasma approximately 90% of the radioiodine, when administered without carrier, was converted into diiodotyrosine and thyroxine.

The destructive effect of carrier free iodine upon the thyroid tissue of rabbits and dogs without perceptible radiation effects upon any other tissues has been demonstrated. Complete destruction of the entire gland without either physiological or histological changes to the parathyroids in rabbits and dogs has been observed. The quantity of radioiodine required was 300 microcuries of I^{131} per kilogram which produced a thyroid irradiation of over 25,000r. Smaller amounts of radioiodine without inert carrier have been employed in the treatment of a few cases of hyperthyroidism with complete and prolonged remission of all of the clinical evidences of this type of thyroid disorder. The dose required ranged from 1 to 1.5 millicuries of I^{131} (20 to 30 microcuries per kg of body weight). The internal thyroid irradiation was estimated to have been from 1000 to 3000r.

MDDC - 1061 Technical Progress Report on the Metabolic Studies of Fission Products, by J. G. Hamilton, 2 p., April 1944. (CH-1572 [A-2240]).

Incomplete tracer studies with plutonium indicate that less than 0.05% of this element is absorbed from the digestive tract in any of the three valence states. The behavior of plus 4 plutonium following intramuscular and intrapulmonary administration is very similar to that of zirconium. The metabolic properties of plus 3 and plus 6 plutonium are very similar to those of yttrium and plus 3 uranium.

MDDC - 1062 Tracer Studies on Fission Product Metabolism, by J. G. Hamilton, 7 p., February 2, 1945. (CH-2673).

Radioactive isotopes, free from inert carrier, of Sr, Y, Zr, Cb, Ru, Te, Cs, Ba, La, Pr, Ce, and Np were administered to rats as chlorides in isotonic solutions of NaCl at pH ranging from 2.3 to 3.5.

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Iodine was given as NaI, and Xe was given by inhalation in an oxygen-gas mixture. Unseparated fission products, free from inert carrier and uranium, after 90 days cooling were administered in an isotonic solution of NaCl at pH 2.5.

Adult rats received the various radioactive preparations in solution by oral, parenteral, and intrapulmonary administration. In the earlier experiments the parenteral administration was by way of the intraperitoneal route. Due to the difficulty of absorption of some of the radioactive isotopes, considerable retention of activity on the surfaces of the intra-abdominal organs took place. In order to gain a more accurate picture of the true deposition of these radioactive isotopes in the intra-abdominal organs it became necessary to employ the intramuscular route of administration.

The animals were sacrificed in groups of three for each route of administration and at varying intervals ranging from one to sixty-four days. Sixteen to eighteen representative tissues were removed from each animal and their activities individually measured.

The most significant conclusions that can be derived in the survey of all of the work done with the long life fission products can be summarized in the following manner: the alkaline earths, rare earths, Zr, Np, and Cb when introduced into the body are deposited primarily in the skeleton, where the average degree of retention of the absorbed radioelement is approximately 50 per cent of the initial absorbed quantity. The retained fractions of these radioelements are eliminated at rates which are less than their rates of radioactive decay with the exception of the 340 day Ce and possibly Sn^{90}. The remaining five long-lived radioelements, Ru, Te, Xe, I, Cs do not show any significant degree of localization in the skeleton and in addition there is no very striking deposition in any other of the tissues with the exception of deposition of I in the thyroid. The rates of elimination for all of these four radioelements are much greater than their rates of radioactive decay, with the exception of I accumulated in the thyroid. In this particular case the release of accumulated I in the thyroid is many times slower than its rate of radioactive decay.

The members of the long-lived fission product group which are absorbed by way of the digestive tract include the alkaline earths, tellurium, iodine, and cesium. A high degree of retention by the lungs has been observed following direct intrapulmonary administration of the rare earths, Zr, Cb, Ru and Np. The pulmonary retention observed for the alkaline earths, Te, I, and Cs is negligible under the conditions of the experiment.

MDDC - 1063 Films of Trinity Tanks and Rocket Samplers, Los Alamos, 1 p., n.d., decl. 6/27/47.

The complete text of the report is reproduced below.

In this film is shown first a general panoramic view of the field laboratory buildings used at the atomic bomb test site at Trinity, New Mexico, in preparation for the first atomic bomb test prior to July 16, 1945.

Next are shown views of two General Sherman, M-4, medium tanks. These tanks were stripped of their armament and equipped as follows.

The first tank seen was equipped to project the five rockets shown mounted on it into the center of the crater from a distance of about 500 yards. The rockets were equipped with sampling noses which could retain earth samples obtained upon impact. Immediately beneath each rocket as shown mounted on the tank is a drum for retaining a cable attached to and used to withdraw the spent rocket with its earth sample from the bomb crater after the rocket has been fired into the crater. To the earth

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sampling head of each rocket was attached a small container of pyrotechnic material which was ignited as the rocket was released. This pyrotechnic material supplied the white smoke trail by which each rocket can be traced during its flight.

The second tank used is shown in the later portion of the film. It was used to go directly into the crater within four hours after the explosion of the bomb to recover earth samples. This tank had a lead lining to afford a driver and observer, within it, shielding from gamma rays radiating from the earth of the crater formed and activated by the bomb. The thickness of the lead was determined on an estimated safety factor of forty. The driver and observer were housed in separate compartments. Dust from the crater floor was collected by means of a vacuum cleaner and drawing samples through a hole in the floor of the observer's compartment. Alternately, core samples of earth were collected by driving a hollow pipe into the ground through this hole in the observer's compartment.

MDDC - 1064 Theory of the Slowing Down of Neutrons by Elastic Collisions with Atomic Nuclei, by R. E. Marshak, 99 p., 1946. (LADC-405). (See also Review of Modern Physics, Vol. 10, p. 185-238, July 1947.)

This article gives a review of the present status of Slowing Down Theory. It presents detailed information on the zero and second moment of the distribution function in an infinite median for arbitrary energy dependence of the mean free path and also the available results for the higher moments. Approximate representations of the distribution function itself are also discussed.

The article is divided into the following topics: introduction and fundamental equations; energy distribution of slowed down neutron; stationary case, time-dependent case; spatial distribution of slowed down neutrons; second spatial moment of the neutron density; higher spatial moments of the neutron density; age theory; neutron density throughout space.

A bibliography of 42 references is included.

MDDC - 1065 Photographic Film as a Pocket Radiation Dosimeter, by L. A. Pardue, N. Goldstein, and E. O. Wollan, 11 p., April 8, 1944. (CH-1553 A-2223).

It is desirable to keep exposures whenever possible below the best estimate of the tolerance upper limit, but when an exposure goes outside this range its value should be known. A film meter with its range up to about 20 r will lose very few exposures. Its accuracy in routine measurements is believed to be better than 25%. In this latter regard it compares quite favorably with pocket chambers and it does not have the present range limitation (0.2 r) of those chambers where leakage, jars, and tampering produce the same effect as radiation. The reliability of film meters will not change with time and film blackening almost certainly will be the result of radiation. Pocket chambers excel in allowing the integrated dose to be read quickly. This is an important advantage when one wishes to follow an exposure during the course of an experiment or any other job where the material handled is known to very active. Until a single method with the advantages of both films and ion chambers is developed there will be a need for using both types. At the present time no routine method is available which measures exposures to a high degree of accuracy. However, if the worst were true and the accuracy were no better than 50% the effort would still be justified.

Pocket meters can of course not be expected to replace radiation surveys which should be made regularly in order to establish the general radiation conditions which prevail in the areas. These are

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necessary for finding high local intensities such as beams from imperfect shields, and beta ray sources for which the present pocket meters are not designed. Special surveys must take care of fast neutron radiation and atmospheric contamination.

Photographs of parts of the film badge and exposed films are included.

MDDC - 1066 The Clinical Sequence of Physiological Effects of Ionizing Radiation in Animals, by C. L. Prosser, et al., 3 p., n.d., decl. 6/24/47.

This report comprises new material to be added to MDDC-611.

Hemorrhages were frequently seen at autopsy in the kidney, particularly near the junction of the cortex and the medulla. Histologically the kidney rarely shows damage after external irradiation. However, continued irradiation from injected polonium in rabbits and from high doses of plutonium (1.5-2μg/g or 0.0937-0.125μc/g) in rats does cause kidney damage.

In rabbits, the maximum tissue destruction appears to occur in the first two days. Measurements of metabolic balance after injections of radioactive materials are less extensive than after X-irradiation, but the general picture appears to be similar.

The effect of irradiation appears to be an acceleration of normal catabolism, particularly in the acute lethal period. The correlation between the therminal negative nitrogen balance and death is very striking. If it were possible to prevent the tissue destruction that occurs about 2 weeks after irradiation, it might be possible to prolong life.

Excretion of creatine, but not of creatinine, declined in two X-rayed dogs in the intermediate period, and then rose in the acute terminal period. Excretion of urea N was relatively constant. Spectrophotometric analysis of urine showed an increase in excretion of kynurenic acid as dogs entered their terminal period; this suggest altered tryptophan metabolism. Uric acid excretion also rose terminally in dogs. The relative increase of uric acid as compared to allantoin was believed due to liver dysfunction and inhibition of (liver) uricase activity.

During the intermediate period, blood NPN declines in dogs by 25-40 per cent; urea N and "polypeptide" N decline by smaller proportions. Terminally, NPN, urea N, and "polypeptide" N all show a marked rise. Similar late increases in NPN were found in rabbits.

Bibliographical references are included.

MDDC - 1067 Preliminary Compilation of Data on the Non-Fission Nuclei, by W. H. Sullivan, 12 p., n.d., decl. 6/12/47.

This preliminary compilation lists the class, abundance, type of radiation, half life, particles, γ rays, and methods of production of the non-fissionable nuclei.

A bibliography of 91 references is included.

MDDC - 1068 Artificial Radioactive Isotopes of Polonium, by D. H. Templeton, J. J. Howland, and I. Perlman, 22 p., March 26, 1947. (BC-45). (See Physical Review, Vol. 72, p. 758-765, November 1, 1947.)

Three new isotopes of polonium have been prepared by bombarding isotope-enriched lead samples with helium ions and bismuth with protons and deuterons. Evidence is given for their assignments as follows:

Isotope	Half-life	Decay	Radiations	Produced by
Po^{206}	9 days	K(90%), α (10%)	X-rays, e^-, γ 0.8 Mev, α 5.2 Mev	$Pb^{204}(\alpha, 2n)$
Po^{207}	5.7 hours	K(~100%), α(0.01%)	X- rays, e^-(?), γ 1.3 Mev, α 5.1 Mev	$Pb^{206}(\alpha,3n)$
Po^{208}	~ 3 years	α	α 5.14 Mev	$Pb^{207}(\alpha,3n)$ $Bi^{209}(p,2n)$ $Bi^{209}(d,3n)$

The 9-day Po^{206} has been shown to decay to 6.4-day Bi^{206}. No daughter activities of Po^{207} and Po^{208} have been found. No activity has been found for Po^{209}. Also, 110-min F^{18} (β^+) has been prepared by the reaction $O^{16}(\alpha,pn)F^{18}$ or $O^{16}(\alpha,2n)Ne^{18}$ short F^{18}.

Graphs and a bibliography of 40 references are included.

MDDC - 1069 Artificial Radioactive Isotopes of Polonium, Bismuth, and Lead. Chapter IV. A New Reaction with High Energy Deuterons, by D. H. Templeton, 6 p., n.d., decl. 6/6/47. (BC-53).

The formation of At^{211} has been observed when bismuth was bombarded with high energy deuterons. This cannot be explained by impurities in the target or helium in the ion source. A reaction of the type (d,β^-) is unreasonable for theoretical reasons. A reaction of the type (d,μ^-) where μ^- represents a negative mesotron, cannot explain the phenomenon in every case. An explanation which is consistent with the observed facts assumes that secondary alpha particles produced by the incident deuterons in turn cause the $Bi^{209}(\alpha,2n)At^{211}$ reaction. Reasonable cross sections for the two steps in this mechanism account for the observed yield.

MDDC - 1070 Toxicity of Certain Heavy Metal Carbonyls ($Ni(CO)_4$, $Mo(CO)_6$, $W(CO)_6$, $Cr(CO)_6$), by C. Voegtlin, 4 p., March 20, 1945.

$Ni(CO_4)$ has a relatively high toxicity. The symtoms, pathological findings, diagnosis and treatment are reviewed. Recommendations are made for prevention of damage.

The industrial use of $Mo(CO)_6$, $W(CO)_6$, and $Cr(CO)_6$ should not present any serious health hazards if the operation does not involve temperatures exceeding ordinary atmosphere conditions and the inhalation of the compound in the form of dust.

As the toxicity of Cr, Mo and W in ionized compounds, it should be remembered that Cr as chromic acid can produce perforation of the nasal septum and other local reactions. The toxicity of Mo and W

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as shown by a few experiments on animals may be regarded as relatively low. There is no evidence of industrial tungsten poisoning in spite of its extensive use.

The heavy metal alkyls $Pb(CH_3)_4$, $Zn(CH_3)_2$, $Sn(CH_3)_4$ are absorbed from the lungs and chronic poisoning results. Proper precautions should be taken to avoid exposure of workers to the vapors of these alkyl metal compounds.

MDDC - 1071 Calculation of Neutron Distributions in Heterogeneous Piles, by A. M. Weinberg, 13 p., n.d., decl. 5/19/47.

The calculation of the slow neutron density in a pile which consists of lumps of uranium disposed in a lattice is a problem of fundamental importance in elementary pile theory. A calculation is presented which is similar to the method used for calculating the distribution around control rods.

MDDC-82 provides some background for this report.

MDDC - 1072 Szilard-Chambers Reaction. II. The Enrichment of Sb Activity, by R. R. Williams, Jr., et al., 21 p., n.d., decl. 6/20/47. (ANL-HDY-183).

A search for a compound of Sb suitable for use in a Szilard-Chalmers enrichment reaction has been undertaken. Several compounds have been found which satisfy the basic criteria of separability and non-exchange, but in every such case, excessive radiation decomposition or loss of separable activity has prevented the production of large quantities of activity. The data on SbF_5, where radiation loss of separable activity occurs, have been compared with the theoretical expression developed in the first paper of this series (MDDC-1055). See also MDDC-1281.

MDDC - 1073 Thermal Neutron Flux in the Argonne Heavy-Water Pile, by W. H. Zinn, 1 p., March 28, 1947. (ANL-WHZ-81).

This report is reproduced in its entirety.

This pile is normally operated at a power in the neighborhood of 300 kw. For experimental reasons there sometimes are very considerable departures from this value. Irradiation of chemicals and materials is usually carried out either in a thimble centrally located in the pile, or a region in the reflector of the pile near the peripheral boundary.

The thermal neutron flux in the central thimble is definitely dependent upon what materials are in the thimble. As a general rule, however, this flux is approximately 10^{12} neutrons/cm^2/second.

MDDC - 1074 Folic Acid Therapy. Results of a Clinical Study, by W. S. Adams and J. S. Lawrence, 25 p., June 12, 1947. (II-188-7029).

Results of a study of thirty-four cases of varying types of blood dyscrasias treated with folic acid show that:

Folic acid will correct the abnormal blood findings in cases of pernicious anemia in relapse.
It is likely that the neurological manifestations of pernicious anemia are not corrected by folic acid.
In pernicious anemia the reticulocyte response in liver treated patients differs from that obtained in folic acid treated patients.
It is probably unwise to combine folic acid and iron in the treatment of pernicious anemia.
Sprue responded favorably to folic acid administration (one case).
All macrocytic anemias do not respond to the administration of folic acid. In those cases in which there is a megaloblastic arrest in the bone marrow, favorable results can be anticipated.
Folic acid did not affect the anemia associated with chronic nephritis.
The administration of folic acid did not alter the leukopenia associated with either Addison's disease or Felty's syndrome (one case each).
The apparent effect of folic acid upon the level of granulocutes in one case of thiouracil agranulocytosis was probably coincidence for others have reported no effect.
Folic acid had no effect on the leukopenia of idiopathic states.
No beneficial effect was noted in two cases of leukemia treated with folic acid.
Folic acid did not correct the leukopenia induced by roentgen radiation.

MDDC - 1075 The Exchange Adsorption of Ions from Aqueous Solutions by Organic Zeolites, II. Kinetics, by G. E. Boyd and A. W. Adamson, 49 p., n.d., decl. 7/7/47. (See Journal of the American Chemical Society, Vol. 69, p. 2836-2848, November 1947.)

Using radio-isotopes as indicators (14.8h Na^{24}; 19.5d Rb^{86}; 1.7y Cs^{134}) and a special "shallow-bed" technique, an extensive survey has been made of the rate constants for ion-exchange adsorption reactions of the type: $A^+ + BR = AR + B^+$. Data were obtained for H^+ , Li^+ , Na^+ , NH_4^+, K^+ , Rb^+ and Cs^+ ions in their chloride solutions.

With solutions greater than 0.1 M in concentration the velocities of ion-exchange followed a diffusion relation:

$$Q/Q_\infty = 1-6(6/\pi^2) \sum_{n=1}^{\infty} (1/n^2) \exp. (-D^i n^2 \pi^2 t/r_o^2)$$

where Q/Q_∞ was the fractional attainment of equilibrium at time t; r_o, the average equivalent spherical radius of the adsorbent particles (Amberlite IR-1), and, D^i, the internal diffusion constant. Values of D^i were seemingly independent of particle size and salt concentration.

With dilute solutions ($<3 \times 10^{-3}$ M) the exchange rates conformed to an equation of the type:

$$Q/Q_\infty = (1 - e^{-RT})$$

where the constant, R, was given by $3 D^l /r\Delta r_o$, K, where D^l was the diffusion constant for the mixed electrolyte solution; Δr_o, a fluid film thickness parameter; and, K, the equilibrium distribution ratio. Constant values of the ratio $D^l /\Delta r_o$ were observed for systems of varying K and r_o. Values of R were found to increase linearly with the linear flow velocity.

MDDC - 1076 Hemophilia: A Report of the Mechanism of the Development and Action of an Anticoagulant in Two Cases, by C. G. Craddock, Jr. and J. S. Lawrence, 27 p., June 3, 1947. (II-188-7001).

This report presents the observations made on two cases of hemophilia in which a naturally occurring anticoagulant was found. These cases, one of which was previously reported by Lawrence and Johnson (1941), with the addition of a third case reported by Munro and Jones, comprise the only instances in which an anticoagulant has been observed and reported.

Both patients were typical hemophiliacs. Each in the past had been observed to develop a refractory phase to transfusion of fresh whole blood or plasma. On the present admission for bleeding both exhibited refractoriness to transfusion therapy and to injection of antihemophilic globulin of Cohn. In one case no benefit at all resulted; in the other, there was very transient benefit to initial therapy which rapidly gave way to a completely refractory state.

By mixing blood from these patients with normal blood in various proportions, it was found that the hemophiliac blood from these cases had the ability to prolong the coagulation time of normal blood. Control tests using ordinary hemophiliac blood exhibited no such phenomenon.

Studies were made to determine the nature of this anticoagulant. It was clearly demonstrated not to be an anti-thromboplastin, anti-prothrombin, anti-thrombin or antifibrinogen. Toluidine blue did not inhibit its activity, indicating the active principle was not heparin. It was demonstrable in both serum and plasma though not as strongly in serum as in plasma or whole blood. By electrophoretic fractionation it was found to be associated with the gamma globulin.

These findings raised the question as to whether this anticoagulant might not be an antibody to the active principle present in normal blood and in antihemophilic globulin of Cohn but diminished or absent in hemophiliac blood. Such an antibody might result from repeated transfusions or injections of antihemophilic globulin such as these patients received. Positive precipitin tests were obtained using the sera of these hemophiliacs against dilutions of Fraction I of Cohn (containing a large amount of antihemophilic globulin) and against dilutions of normal plasma. Control tests were negative. Further, the sera of these patients were found to inhibit the in vitro activity of antihemophilia globulin after incubation with it, whereas normal sera or sera from hemophiliacs not exhibiting this anticoagulant did not.

On the basis of this evidence the following hypothesis is suggested. Hemophiliacs are deficient or lacking in some globulin factor found in normal blood and necessary for coagulation. In certain instances where this is supplied by repeated transfusion or injection of antihemophilic globulin the recipient hemophiliac is immunized as against any foreign protein. The antibody thus developed acts as an anticoagulant to normal blood and results in refractoriness to further transfusions or injections. It is not clear whether a hemophiliac must be completely lacking in this factor in order to develop this antibody. It is suggested that this anticoagulant possibly may be found in other hemophiliacs refractory to therapy. Further investigation is being carried out as regards this point.

MDDC - 1077 Stars in Photographic Emulsions Produced by Particles Accelerated by the Cyclotron, by E. Gardner, 10 p., June 12, 1947. (BP-71).

MDDC - 948 is an abstract of this report.

MDDC - 1078 Vacuum Melting and Casting of Beryllium, by E. Gordon, 16 p., September 1945. (ANL-HDY-75). (See Metal Progress, Vol. 52, p. 387-390, September 1947.)

Methods are given for melting and casting Be into cylindrical shapes from 1 to 4 1/2 inches in diameter. Mold composition (BeO) and design which give desired results are described, but further research is necessary. Voltages required for radiographing various thicknesses of Be are given.

Four diagrams of apparatus are included.

MDDC - 1079 Mass Spectrometer: Trochotron, by G. W. Monk, J. D. Graves, and J. L. Horton, 1 p., April 2, 1947. (Review of Scientific Instruments, Vol. 18, p. 796, October 1947).

The complete document is reproduced below.

A large mass spectrometer in which the ion paths are prolate trochoids has been built, following the design principle of Bleakney and Hipple, and has been in operation several months. This "trochotron" uses the theoretically perfect double focussing properties of crossed uniform electric and magnetic fields. The distance between the source and receiver slits in the grounded plate is 40 cm, while in most other particulars the construction is similar to the prolate instrument described by Bleakney and Hipple. An all metal vacuum system is employed. An internal voltage divider is used for the aluminum "picture frames" that establish the electrostatic field.

Operation with collector currents as high as 0.3 microampere has been entirely satisfactory for masses up to Ce^{140}, the heaviest element studied extensively. The resolution is approximately one-half the value expected from geometrical consideration using slits 0.020 inch wide and 3 inches long. Modifications of the apparatus are to be used in separation of stable isotopes in pure microgram quantities and isotopic analysis.

MDDC - 1080 Los Alamos Fast Reactor, by D. B. Hall and J. Hall, 2 p., n.d., decl. 6/27/47. (LADC-406).

The Los Alamos Scientific Laboratory has announced the initial operation of a new type of neutron reactor which operates on the fission of plutonium by high energy neutrons. The fact that the fission process proceeds by use of high energy neutrons has led to the name of "fast" reactor. Since the other existing reactors in the United States use uranium as the active material and thermal or slow neutrons for producing fission the fast reactor is new in the field of atomic energy developments.

The entire reactor is surrounded by a concrete and steel shield of sufficient thickness to reduce adequately the intensity of these radiations. Experiments can thus be carried out adjacent to the reactor without danger or inconvenience.

Numerous facilities are provided for irradiating materials in the neutron flux of about 10^{12} neutrons per cm^2 per second and for allowing intense beams of moderately high energy neutrons to emerge from the reactor. In order to increase the versatility a graphite thermalizing column is provided on one side of the reactor so that both fast and slow neutrons are available for experimental studies.

MDDC - 1081 Angular Distribution of Neutrons from Targets Bombarded by 190 Mev Deuterons, by A. C. Helmholz, E. M. McMillan, and D. C. Sewell, 15 p., June 4, 1947. (BP-74).

MDDC-951 is an abstract of this report.

MDDC - 1082 Cloud-Chamber Energy Measurement of Photo-Neutron Sources, by D. J. Hughes and C. Eggler, 15 p., June 6, 1947. (ANL-HDY-188). (See also Physical Review, Vol. 72, p. 902-907, November 15, 1947.)

The energy distributions of the neutrons from several photo-neutron sources have been measured by means of the range distribution of recoil protons produced in a hydrogen-filled cloud-chamber. It is shown that slowing-down in the source itself produces a broad spread in energy instead of the almost mono-energetic spectrum to be expected from a single γ-energy. The values of the mean neutron energy, E, and the maximum energy, E_M, for the sources measured are as follows:

Source	E (kev)	E_M(kev)
Na-Be	800	1020
Na-D_2O	220	320
Mn-Be	300	375
	<150	<150
In-Be	300	375
	<150	<150
Sb-Be	35	68

As the E_M values should be directly related to the energies of each of the γ sources, they are compared to the γ energies as reported by different observers for each source.

MDDC - 1083 Delayed Neutrons from Fission of U^{235}, by D. J. Hughes, J. Dabbs, A. Cahn, and D. Hall, 33 p., April 25, 1947. (CP-2094). (See Physical Review, Vol. 73, p. 111-124, January 15, 1948.)

The periods, yields and energies of the delayed neutrons from U^{235} have been measured with the pneumatic transfer apparatus ("rabbit") of the D_2O pile machine. The following periods account for the saturated decay curve of delayed neutrons for times longer than 0.2 second after irradiation ceases.

Half-Life	Energy	Relative Yield (corrected for energy)
55.6 sec.	250 kv	0.153
22.0	560	1.000
4.51	430	1.28
1.52	620	1.45
0.43	420	0.51

MDDC - 1084 The Isotopic Constitution of Lanthanum and Cerium, by M. G. Inghram, R. J. Hayden, and D. C. Hess, Jr., 7 p., April 21, 1947. (See Physical Review, Vol. 72, p. 967-970, November 15, 1947.)

The isotopic abundances of lanthanum and cerium have been determined by means of a mass spectrometer. In addition to the known lanthanum isotope of mass 139, a new isotope of mass 138 and abundance 0.089% has been discovered. Since this isotope is isobaric with two neighboring stable isotopes it should be radioactive. This activity was observed and the half-life found to be approximately 2×10^{10} years. Upper limits for the non-existence of other lanthanum isotopes were determined. The abundance of cerium isotopes of masses 136, 138, 140, and 142 were shown to be 0.193%, 0.250%, 88.48%, and 11.07%, respectively. Upper limits for the non-existence of other cerium isotopes were determined.

MDDC - 1085 Radioactivity of Cu^{60}, by C. E. Leith, A. Bratenahl, and B. J. Moyer, 6 p., n.d., decl. 7/9/47. (BP-79). (See Physical Review, Vol. 72, p. 732-733, October 15, 1947.) See also MDDC - 1009.

A positron activity with a half-life of 24.6 ± .3 minutes has been assigned to Cu^{60}. γ radiation associated with this decay has an energy of 1.50 ± .05 Mev and the upper limit positron energy is 2.50 ± .25 Mev.

The 81 sec and 7.9 min positron activities produced by proton bombardment of Ni observed by Delsasso, et al., and tentatively assigned to either Cu^{58} or Cu^{60}, correspond to 81 sec and 10 min activities observed after bombarding Ni^{58} with protons in the 37" cyclotron. These are tentatively assigned to Cu^{59} and Cu^{58}, respectively, on the basis of threshold and excitation considerations. The longer life was shown to be a Cu activity by chemical separation.

The 3.4 hour half-life activity assigned to Ca^{61} was verified by being produced in a $Ni^{61}(p,n)$ reaction.

The 10.5 min half-life activity assigned to Cu^{62} was also verified but the half-life was found to be 10.1 ± .1 min in measurements made through 6 half-lives.

MDDC - 1086 Graphical Surface Area Calculations for the Brunauer, Emmett and Teller Adsorption theory, by F. T. Miles and W. G. McMillan, 20 p., n.d., decl. 7/7/47.

A graphical method is presented for rectifying the isotherms of physical gaseous adsorption according to the theory of Brunauer, Emmett, and Teller, and for reading directly from this rectified plot the values of two adsorption parameters, v_m and c, which give, respectively, the extent of adsorbent surface and the energy of the adsorption process. This method clearly illustrates the dependence of the character of the BET line on the adsorption parameters. An alternative plot of the BET equation due to Dr. T. W. DeWitt is also discussed, and is shown to compliment the usual plot by emphasizing a different range of the energy parameter c. Details of a typical surface area determination are given, illustrating the use of the "Adsorption Plotting Paper."

MDDC - 1087 Chemical Problems in Stable Isotope Separation, by A. J. Miller and B. S. Weaver, 13 p., n.d., decl. 5/23/47. (AJM-66-1).

In the program of separating isotopes by the electromagnetic method the division has engaged in preparing charge materials for the electromagnetic units, recovering, chemically purifying, and analyzing the separated isotopes, chemically reconditioning the units, and preparing mass spectrometer charges from the isotope concentrates for determinations of isotopic abundance. To date 19 elements have been processed and concentrates of 63 different isotopes made available to the Manhattan Project. Most of these isotopes are not radioactive. The concentrates and typical spectrographic chemical analyses are listed in tables. Isotopes of several of the 19 elements and those of silicon, zirconium and antimony are in various stages of chemical purification.

Difficulties encountered in the separations are reviewed and some recommendations made.

MDDC - 1088 A Remark on the Note, "The Mechanism of Nitrogen Pentoxide Decomposition," by R. A. Ogg Jr., by O. K. Rice, 2 p., n.d., decl. 7/9/47.

The decomposition of nitrogen pentoxide remains first order to extremely low pressures, of the order of 0.01 mm. Kassel has shown that to account for this it is necessary, using the most probable model for the system of oscillators comprising the molecule, to suppose that the diameter for collisional activation and deactivation is about 20×10^{-8} cm. Recently Ogg has made an ingenious suggestion which appears to account for this characteristic of the reaction, as well as a number of other features without any excessive collision diameters. It is supposed that the equilibrium

$$N_2O_5 \rightleftharpoons NO_3 + NO_2$$

is established, and that the dissociated products of this equilibrium can occasionally react

$$NO_3 + NO_2 \longrightarrow NO_2 + O_2 + NO$$

to give the decomposition. Working out this mechanism shows that the reaction should be first order to arbitrarily low pressures; the apparent observed falling off in the rate constant at very low pressures presumably indicates that an appreciable fraction of the N_2O_5 is dissociated.

The activated state of the molecule is actually the separated pair $NO_2 + NO_3$ which has an extremely high entropy. The rate of activation can, therefore, be large. In fact, the difference in entropy between the activated and normal states increases with decreasing pressure in such a way as to render the rate of activation independent of the pressure. But the assumption that activation occurs while the parts of the molecule are separated is essentially a device for increasing the rate of activation.

MDDC - 1089 The Radioactivities of Cobalt 61 and 62, by T. J. Parmley and B. J. Meyer, 7 p., n.d., decl. 7/10/47. (BP-72).

Two new radioactive isotopes, cobalts 61 and 62 were obtained by bombarding two samples of nickel enriched in isotopes 61 and 62, respectively, with fast neutrons from the Crocker Laboratory's 60-inch cyclotron. In these experiments the counting was done with a Geiger tube connected to a scaling circuit of 64, which in turn operated a mechanical register.

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Cobalt 61 was produced by following reactions: n,p on Ni^{61}, n,α,n on Cu^{65}, p,α on Ni^{64}, and d,α,n on Ni^{64}. Its chemical position and mass position were determined, respectively, by chemistry and mass analyses.

A n,p reaction in nickel 62, produced radioactive cobalt 62.

In producing radioactive cobalt 62, essentially the same procedure was followed as with cobalt 61 in obtaining absorption data for the new activity. Nickel 62 was activated with neutrons and absorption data obtained, using both aluminum and lead absorbers.

MDDC - 1090 Cloud Chamber Study of the Particles in the Neutron Beam of the 184" Cyclotron, by W. Powell, 6 p., June 12, 1947.

The complete text of the report is reproduced below.

The 200 million electron volt deuterons made by the 184-inch cyclotron strike an internal target and produce a beam of neutrons which come out through the 1.25 inch thick steel wall of the vacuum chamber of the cyclotron. This beam of neutrons drops to half value at an angle of five degrees from the tangent to the deuteron beam striking the target. A large Wilson cloud chamber was placed in the neutron beam at a point 35 feet from the target. The recoil protons produced by the neutrons in matter surrounding the cloud chamber were observed with the purpose of finding the maximum energy of the protons and thereby the maximum energy of the neutrons in the neutron beam.

The circular cloud-chamber 15 3/4 inches in diameter is equipped with a pulsed magnetic field of 9400 oersteds produced by a pair of Helmholtz coils. The cloud chamber timing circuit turns on the field, expands the chamber, turns on the cyclotron oscillator and pulses the arc source of deuteron ions in the proper sequence. The tracks produced in the chamber are very sharp and free from turbulence so that the energies of 200 Mev protons can be determined to within plus or minus ten per cent.

A double camera 52 inches from the cloud chamber with lenses separated by 4.5 inches takes two pictures of the chamber. These are reprojected together on a ground glass screen the plane of which can be rotated and placed at proper distance to recombine the tracks. The projector is identical with the camera so that the reprojected tracks are life size. The curvatures of the tracks are measured directly on the ground glass by matching them with circles drawn on lucite. The error in measurement for a track amounts to plus or minus five per cent for an arc of two meter radius and twelve inches in length.

The films were examined with the purpose of finding the highest energy particles. Out of approximately 8000 tracks four were discovered which had energies between 150 and 200 Mev. A thorough examination of all the photographs has not yet been made and at present the high energy protons are being sent through several centimeters of lead as a check on these pictures. It is quite possible that more particles of this energy will be found as the search continues.

Qualitatively it is possible to account for these high energies by the following argument. When the deuterons strike the target the proton is knocked off and remains inside the cyclotron. The remaining neutron continues on and passes through the cloud-chamber. However, the neutron may, at the instant the proton is stripped off, possess a velocity with respect to the center of mass of the deuteron. This velocity can be in such a direction as to add to the velocity corresponding to half the kinetic energy of the deuteron (which is 195 Mev), and give a neutron with considerably more energy than 1/2 x 195 Mev.

Although at first sight these results appeared difficult to explain it is reasonable to hope that more detailed calculations and more accurate measurements will be in agreement.

MDDC - 1091 Note on the Relation between Entropy and Enthalpy of Solution, by O. K. Rice, 15 p., n.d., decl. 7/9/47. (Journal of Chemical Physics, Vol. 15, p. 875-879, December 1947).

The relation between entropy and enthalpy of solution for a series of non-polar solutes in a given non-polar solvent is discussed. It is considered that solution of a gaseous solute, without changing its concentration on going from gas phase to liquid solution phase, does not change its entropy, all change of entropy being referred to the solvent. The entropy of the solvent changes because of surface effects around the solute molecule, and a kind of long range order introduced by the solute molecules. Two extreme cases are considered, (1) the case of an ideal solution, and (2) the case of a solute of hard attractionless sphere. The difference in entropy of solution between these extreme cases can be estimated. It can also be estimated by extrapolation from the experimental data on the entropy and enthalpy of solution, and these two estimates agree in order of magnitude. The fact that the relation between entropy and enthalpy of solution is linear is also shown to be a reasonable expectation, and effect of changing solvent as well as solute is considered. The groundwork is thus laid for a qualitative understanding of this relation between entropy and enthalpy of solution.

MDDC - 1092 Some Operating Phenomena Associated with the 184-Inch Cyclotron, by D. C. Sewell, L. Henrich, and J. Vale, 6 p., June 13, 1947. (BP-73).

The abstract of this document has previously been issued as MDDC - 1020 and listed in this journal.

MDDC - 1093 The Separation of Rare Earths by Ion-Exchange. III. Pilot Plant Scale Separations, by F. H. Spedding, et al., 30 p., n.d., decl. 7/10/47. (See also Journal of the American Chemical Society, Vol. 69, p. 2812-2818, November 1947.)

Detailed procedures are given for the large scale separation of the rare earths using Amberlite IR-100 and 0.5% citric acid ammonium-citrate solutions as the eluant. The process employed 24 columns 4 inches in diameter and with 8 feet of resin bed length. The pH of the citrate eluant was 3.9; the growth of mold was eliminated by the use of 0.1% phenol. Large samples of rare earths, of high purity were obtained by these procedures. Examples of the quantity and quality of several fractions on hand include: (1) neodymium: 800 gm 99.9% Nd_2O_3, 0.1% Pr_6O_{11}; 770 gm 98% Nd_2O_3, 2% Pr_6O_{11}, (2) praseodymium: 35 gm 99% Pr_6O_{11}, 1% Nd_2O_3; 160 gm 90% Pr_6O_{11} (impurities Ce, La and Ca); (3) samarium: 160 gm 99.9% Sm_2O_3; 600 gm 99% Sm_2O_3, 0.5% Eu_2O_3, 0.5% Ca. In addition, considerable quantities of slightly impure heavy rare earth salts and yttrium salts have been prepared.

MDDC - 1094 Spectrophotometric Evidence for the Existence of Uranium Pentachloride as a Double Compound of Hexa- and Tetrachloride, by C. C. Sterrett and V. P. Calkins, 1 p., n.d., decl. 5/22/47.

This report is reproduced here in its entirety.

The molecular absorption spectra of solutions of UCl_5, UCl_6, and UCl_4 in carbon tetrachloride and thionyl chloride were measured with a Beckman spectrophotometer equipped with a quartz prism and

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an incandescent lamp permitting measurements in the wave length range from 300 mμ. The results obtained indicate that the pentachloride exists as a double halide compound of the hexa- and tetrachloride and not as a simple chloride compound corresponding to its usually assigned formula of UCl_5. Although the tetrachloride gave a decreasing absorption continuum in both the carbon tetrachloride and thionyl chloride solution, the absorption spectra curves for the hexa- and pentachloride showed identical maxima at 650 mμ and 850 mμ in both solvents, thus indicating that the higher two chlorides of uranium undergo the same molecular electronic transitions. By noting the height of the maxima obtained with pure hexachloride solutions and by the use of Beer's law, it was found that the height of the maxima procured with the pentachloride solutions corresponded to that height which should have been attained if the pentachloride used were composed of equimolar amounts of the hexa- and tetrachloride of uranium. This quantitative data corroborated the qualitative data concerning the frequencies at which these maxima occurred.

MDDC - 1095 Nioxime: A Reagent for Palladium, by R. C. Voter, C. V. Banks, and H. Diehl, 7 p., n.d., decl. 7/9/47.

The water soluble 1,2-dioxime, 1,2-cyclohexanedionedioxime, called Nioxime, yields a yellow precipitate with divalent palladium. This precipitate can be used as a qualitative and quantitative reagent for this ion and offers several advantages over its analogue, dimethylglyoxime. It effectively separates palladium from platinum with a single precipitation as well as from other cations. Palladium nioxime can be filtered from a hot solution after a brief digestion period. Qualitatively, nioxime is a more sensitive reagent for palladium than dimethylglyoxime.

MDDC - 1096 Specific Heat, Enthalpy, and Entropy of Uranyl Fluoride, by P. F. Wacker and R. K. Cheney, 12 p., July 20, 1947. (See Journal of Research, National Bureau of Standards, Vol. 39, p. 317-320, October 1947).

The heat capacity of uranyl fluoride was measured from 13° to 418°K using a vacuum-type calorimeter equipped with thermostated radiation shields. From the data so obtained, the enthalpy $H^\circ - H^\circ_{\cdot}$ was calculated to be 63.96, 77.62, and 108.15 int. joules per gram at 298.16, and 338.16, and 423.16°K, respectively, while the entropy was calculated to be 0.4400, 0.4830, and 0.5635 int. joules per degree-gram at the same temperatures. No evidence of a transition was found. The values of the specific heat, enthalpy, entropy, and free energy are tabulated at five degree intervals of temperature.

MDDC - 1097 The Natural Abundance of the Isotopes of Zirconium, by J. R. White and A. E. Cameron, 1 p., n.d., decl. 5/29/47.

The report is reproduced here in its entirety.

The abundance of the isotopes of naturally occurring zirconium were determined in a 60° mass spectrometer of the Nier type. Ions were formed by 50 volt electron bombardment of vapors of zirconium tetrachloride ($ZrCl_4$) and zirconium tetrafluoride (ZrF_4). Ion intensities were measured with a conventional FP-54 electrometer and calibrated potentiometer by the "null" method. Zr^+ ions formed in the tetrafluoride bombardment, were measured.

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Mass	90	91	92	94	96
Zr +	51.51	11.27	17.14	17.30	2.78 Mole %
ZrF_3 +	51.40	11.19	17.09	17.50	2.82
Average	51.46	11.23	17.11	17.40	2.80
Aston: photometry of photographic plate	48	11.5	22	17	1.5

Masses 88,89,93,95,97,98 and 99 are each not present to greater than 1/5000 of the total zirconium ion abundance. An uncertainty of one per cent in each specific ion abundance tabulated appears likely.

MDDC - 1098 Balanced Ionization Chamber for Differential Measurements of Gamma Rays, by C. Wiegand, 6 p., June 18, 1947. (BP-81).

MDDC - 1024 is an abstract of this document.

MDDC - 1099 Ionization Chamber for C^{14} Measurements, by C. J. Borkowski, 3 p., n.d., decl. 6/12/47.

The purpose of this report is primarily to release a design on an ionization chamber, thirty of which have been used for routine C^{14} and H^3 measurement. The ionization currents in all cases were measured with a dynamic condenser electrometer, although a Lindemann electrometer connected to this type of chamber could also be used.

Measuring C^{14} as $C^{14}O_2$ in an ionization chamber possesses the following advantages: A constant reproducible geometry is always obtained; there are no self absorption corrections to apply; increased sensitivity over solid sample counting is obtained; intensities from one disintegration per second to 10^6 disintegrations per second can be measured; up to 1000 ml of CO_2 can be measured. This is equivalent to approximately 8 gms $BaCO_3$; the time required to acidify a sample of $BaCO_3$ and introduce it into an ionization chamber takes no longer than to properly spread an infinitely thick solid sample for G-M counting.

A diagram of the ionization chamber is included.

MDDC - 1100 The Tolerance Dose, by S. T. Cantril and H. M. Parker, 60 p., January 1945. (CH-2812).

An extensive discussion of tolerance dose is given under the following headings: definition of terms; the history of the tolerance dose; the biological aspects of the tolerance dose; dependence of the tolerance dose on the nature of the radiation; legal status of the tolerance dose; and applicability of animal experiments to tolerance dose in man.

A bibliography of 39 references is included.

MDDC - 1101 Remote Control Analytical Apparatus, by R. E. Curtis, 37 p., May 19, 1947.

This report consists of sixteen photographs of analytical apparatus and special devices used in remote control work with a description of each. These include: the remote control panel board; a sampler which enables the taking of a secondary sample from a comparatively large primary sample; a remote control panel unit for spectrophotometric determinations; titration dish tongs which are used to manipulate micro-titration dishes; the wiping tong which is used to hold small pads of absorbent paper used in wiping pipette and burette tips having radioactive materials on their surface; remote control handling tongs generally used in laboratory operations where distance between the operator and the object being handled is essential; a carrier for transporting discs within a counting room; a covered rotary disc carrier and tongs which are used to transport discs which are too hazardous for normal means of carrying and handling; a hooded evaporator for handling highly hazardous solutions; a manipulator for safe manipulation of radioactive solutions; a dry waste disposal shield; a titration shield; and a rotary titration table.

MDDC - 1102 Morpholic Changes in the Lymphocytes of Persons Exposed to Ionizing Radiation, by A. Dickie and L. H. Hempelmann, 22 p., n.d., decl. 7/2/47. (LADC-413). (See Journal of Laboratory and Clinical Medicine, Vol. 32, p. 1045-1059, 1947.)

This study covers a two year period from 1944 to 1946.

Analysis of the total leucocyte counts of persons chronically exposed to ionizing radiation and toxic chemicals shows a significant statistical decrease in the exposed groups.

Analysis of the absolute number and per cent lymphocytes in the differential counts of the same persons show no significant change.

Morphologic study of supravital preparations of blood cells of persons chronically and acutely exposed to ionizing radiation indicates a striking increase in the number of refractive neutral red bodies in the cytoplasm of the circulating lymphocytes. An increase in neutral red bodies is also found in persons working with toxic chemicals.

It is shown that these neutral red bodies have high density and may be considered to be granules. They have not been identified in fixed preparations.

MDDC - 1103 Modified Simpson Methane Flow Proportional Alpha Counter and Fission Counter, by M. S. Freedman, 18 p., n.d., decl. 7/9/47.

This document consists of a series of drawings of the instrument with the following explanation:

The modification of the Simpson Methane flow proportional counter consists of a means for inserting and replacing samples into the chamber through an air-lock device which avoids the introduction of even a small quantity of air into the active volume of the chamber. This is accomplished by sweeping out the small volume of the air-lock containing the sample with methane gas before the sample is introduced into the chamber--this sweeping out requiring only a few seconds.

The mechanical construction is somewhat simplified over that employed in the Simpson counter. design, although the electrical and counting characteristics are essentially duplicates of those employed in the Simpson version. Voltage plateaus about 400 volts long, flat within 1% per 100 volts

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are obtained with the counter, with the operating point at about 2500 volts for methane at one atmosphere pressure. A plateau extending over a range of about 40% variation in amplification factor is obtained. Standard samples have been checked to standard deviation of ±0.3% over a period of one year. The counter is rather gas-tight and is ready for use within about ten minutes after the methane flow is first started. Thereafter counts may be started on samples with reliable results as rapidly as the samples can be changed.

The small size of the whole chamber (less than 4" diameter overall) permits its use as a fission chamber inside one of the small channels in the thermal column of the pile. The sample is mounted upon the sample holder which is re-entrant from the outside (as shown) so as to have only 1/32" of metal between the sample and the outside. By allowing a beam of fast neutrons to enter the chamber through the re-entrant recess (from the bottom as shown in the drawings) fast fissions may be induced in the sample with only a minor diminution in the beam intensity. Thus the chamber may be used as a fast fission chamber. The chamber has been found to work reliably with 15' long shielded cables connecting it to the amplifier and scaler, which would permit the location of the amplifier and scaler far from the magnet of a cyclotron used as a source of fast neutrons.

MDDC - 1104 Nuclear Fission Source of Power, by J. R. Menke, 29 p., n.d., decl. 6/30/47. (See Econometrica, Vol. 15 p. 314-340, October 1947).

An estimate is made of the cost of producing useful electric energy from nuclear fission processes. A description of a pile from an economic viewpoint is given together with a discussion of its products. The significance of the available resources is then estimated. A comparison is given of the breakdown of cost items in producing coal-steam electric power and nuclear fission electric power. It is found that these costs lie in the same range as other heat-engine costs but lie above typical hydro-electric costs. A fairly extensive bibliography is appended.

MDDC - 1105 Spectrophotometry of Plutonium (VI) in Perchlorate Solutions, by G. E. Moore and K. A. Kraus, 44 p., May 1947.

The absorption spectra of plutonium (VI) in 1 M $HClO_4$ solutions were studied with a Beckman quartz spectrophotometer, Model DU. Beer's Law and Lambert's Law studies of the prominent plutonium (VI) peaks were carried out. The pronounced deviation from Beer's Law of the peak near 830 millimicrons readings is very strong and specific, and was found to be quite suitable for analytical work, provided that empirical curves relating optical density, slit width, and concentration of plutonium are obtained. These calibration curves differ for various instruments.

A preliminary study of the absorption spectra of perchlorate solutions of plutonium (VI) up to pH 7 was carried out. The spectrum of plutonium (VI) remains practically unchanged up to pH ca 3.6, when it becomes highly pH dependent, indicating the formation of several hydrolysis products of PuO_2^{++}, and giving strong evidence for a polymerization reaction, in agreement with other hydrolytic work on plutonium (VI).

A bibliography of 15 references is included.

MDDC - 1106 **Adjustable Electrode Arrangement for a Spark Source Mass Spectrograph, by W. Rall and A. E. Shaw, 4 p., June 25, 1946. (CP-3550).**

The design of a convenient electrode mounting for a spark source mass spectrograph is presented. This design is a slight modification of that used on the Mattauch type spectrograph.

MDDC - 1107 **Design of the High Frequency Spark Source for the Mass Spectrograph, by W. Rall, 4 p., June 17, 1946. (CP-3538).**

The various improvements which have been made in the design of the high frequency spark ion are discussed.

This assembly consists of four concentric tubes 6" long. The primary of 5 turns is wound in a groove of 5/16" pitch cut in a lucite rod of 1 1/4" O.D. This is covered by a blank insulating tube of 1 3/4" O.D. Over this tube fits the secondary coil of 200 turns wound in a vee-groove cut 28 threads per inch on a tube of 2 1/4" O.D., covered by another tube of 2 3/4" O.D. The grooves for the secondary windings are cut on a 2 1/16" diameter to allow space for a thick coat of Dow Wax over these windings. The precautions of equal spacing with lucite thread wall separations, of wax coating, and of heavy fermex insulation on the wire have effectively prevented sparking between the various turns of the secondary winding, a difficulty encountered before these precautions were observed.

The problem of making a positive connection to the secondary windings was solved by the use of split rings fastened to the lucite tube at the two ends of the windings.

A condenser of fairly small physical dimensions was found to be satisfactory, 2" x 2 1/2" x 3-3/4" mica capacitors (Cornell Dubilier Type 86 or Aorexex Type 1995). The value of the capacity varies with the other circuit constants in the resonant circuit; .004 Mfd is being used.

The spark gap used most has been a hydrogen filled (atmospheric pressure) gap consisting of two 2 mm tungsten electrodes sealed into a pyrex cylinder with about a 1/4" gap between them. Gap separation was provided by mica washers. This operated quite satisfactorily; however, sputtering from the spark gradually deposited a conducting coat on the mica surfaces causing a short circuit. This was corrected by disassembling and scraping the mica. The hydrogen-gap short circuits less often because of the larger glass surface and can be cleaned quickly by shaking up the carborundum which is sealed in the tube for this purpose. This gap is mounted in a small oil bath for cooling.

A compact unit consisting of lucite Tesla coils, spark gap, and condenser is shown. Later, this assembly was adapted to the oil-cooled hydrogen gap and built around the oil tank.

A neon sign type transformer with a 5000 volt current limited (30 m.a.) secondary was found sufficient to energize the spark circuit.

MDDC - 1108 **Voltage Supplies for the Mass Spectrograph, by W. Rall and A. E. Shaw, 5 p., June 25, 1946. (CP-3549).**

Two D.C. voltage supplies were constructed for the double focussing mass spectrograph with an accelerating voltage of up to 30,000 volts and a deflecting voltage of up to 3500 volts.

Circuit diagrams are appended.

MDDC - 1109 Precision Delayable Sweep (Modified), by E. W. Titterton, 1 p., n.d., decl. 7/10/47. (LADC-354).

A circuit diagram is drawn for a precision delayable sweep circuit to be used in connection with an oscilloscope.

MDDC - 1110 The Fluorination of Polychloroheptanes with Hydrogen Fluoride, by A. R. Van Dyken, 61 p., August 1943.

This document is a thesis.

The purpose of this investigation was to study one step in the preparation of C_7F_{15} from n-C_7H_{16}, namely the reaction of HF with polychloroheptanes in the presence of antimony halides.

It was found that the reaction could be carried out successfully by passing HF gas through a mixture of polychloroheptanes and the reaction was a mixture of polychloropolyfluoroheptanes having an average approximate formula varying from $C_7H_4Cl_5F_7$ to $C_7H_4Cl_6F_6$. Several reactions were carried out to prepare quantities of this material for further work in the preparation of C_7F_{16}, and to determine the best conditions for obtaining as large a yield as possible of material in which at least six of the chlorine atoms had been replaced by fluorine. In general, enough information was obtained concerning the effect of various factors, so that a summary can be made of the best conditions for preparing these polychloropolyfluoroheptanes.

The polychloroheptanes used as starting material should contain as high a percentage of chlorine as can be obtained without causing the formation of too many degradation products due to chlorinolysis. Material containing between 82 and 83 per cent chlorine has proven to be much more satisfactory than that of lower chlorine content. The reaction can be most satisfactorily carried out in a reactor in which the two liquid phases, the organic and the antimony salts, are brought into intimate contact by stirring.

The amount of $SbCl_5$ necessary to produce the desired degree of fluorination is a 0.45 ratio by weight to the polychloroheptanes. Any increase in the ratio of $SbCl_5$ to polychloroheptanes above this value, does not increase the degree of fluorination.

The reaction can be carried out most successfully at atmospheric pressure in a temperature range from 110° to 125°C. At a lower temperature the antimony salts tend to solidify in the latter stages of the reaction, thereby plugging the inlet tube for HF. At higher temperatures some antimony salts tend to sublime from the reaction mixture and cause the outlet to plug.

The smallest mole ratio of HF to organic material which gave satisfactory results was 7.5:1 and was made possible by carrying out the reaction in a Monel reactor equipped with a stirrer. A total of six chlorine atoms was replaced by fluorine in this reaction.

The maximum yields obtained are in the order of 83 to 86 per cent.

A series of experiments was carried out in which the product from this reaction was treated directly with SbF_5, the next step in the process. This was done to avoid losses in washing, and drying the product. In this manner an over-all yield of 81 per cent for the two reactions was obtained.

MDDC - 1111 Excretion of Radium from the Mouse, by J. Weikel and E. Lorenz, 1 p., June 3, 1947.

This document is an abstract of MDDC - 1587, and is reproduced here in its entirety.

The possibility exists that radium will form an organic protein compound and that its excretion might be influenced by BAL (2, 3-dimercaptopropanol). Three groups of C_3H male mice, 50 in each group were injected intraperitoneally with 10 micrograms of radium element as bromide. One group of animals was injected with 5 mgs of BAL daily for the first 20 days; the second group was given the same amount of BAL beginning at the 20th day for 20 days after injection of the radium. The excretion was measured by determining the amount of radium remaining in the animals. For this purpose a multiple Geiger Mueller counter was developed, in the inside of which the animals were placed. The number is described and the excretion data given. It was found that BAL does not influence the excretion of radium either in the acute or in the chronic stage of radium poisoning.

MDDC - 1112 Spiral Carrier, by J. F. Weingart, 2 p., March 26, 1947. (LADC-411).

This spiral attachment is designed to be attached to a standard Leed and Northrup Microdensitometer, used for examining X-ray films. The normal commercial microdensitometers on the market allow only for linear measurement of X-ray films.

In the examination of an X-ray film exposed above and transversely to the longitudinal axis, it is necessary that the light beam used be passed in a spiral manner through the film in order to record accurately the density of the silver layer on paper.

The spiral carrier attachment for the microdensitometer is designed to facilitate the positioning of the film so that at all times during examination light passes through the film at the proper angle. This light is picked up by a photoelectric cell which actuates a recording device.

MDDC - 1113 The Exchange Adsorption of Ions from Aqueous Solutions by Organic Zeolites. III. Performance of Deep Adsorbent Beds under Non-Equilibrium Conditions, by G. E. Boyd, L. S. Myers, Jr., and A. W. Adamson, 43 p., n.d., decl. 7/15/47. (See Journal of the American Chemical Society, Vol. 69, p. 2849-2859, November 1947).

An experimental and theoretical study was made of the uptake of trace amounts of the alkali metal cations from dilute acid solutions by deep beds of granular exchange adsorbents.

Assuming the validity of a first order rate equation based upon a film diffusion hypothesis, the equation governing the concentration of adsorbate in solution, C^l, at any time, t, and at any point within a cylindrical bed was shown to be:

$$(\delta C^l/\delta t) + v\,(\delta C^l/\delta x) = -(1/f)\,k\,\delta(C^l - S),$$

Where v was the linear flow velocity; x, the adsorbent bed depth; f, the fractional bed void; k, the adsorption rate constant; δ, the equilibrium distribution coefficient; and, where $S\,C^s/\delta$, with C^s denoting the actual concentration of adsorbate in the solid. The solution to this equation, for the correct boundary conditions, yields an expression giving the concentration of adsorbate in the effluent from the deep bed in terms of two dimensionless parameters, as follows:

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$$C^1/C_o^1 = e^{-y-z} \sum_{n=o}^{\infty} z^n M_n(yz)$$

where $y = (k\delta/f)(x/v)$; $z = k(t-x/v)$; and where the quantity $M_n(yz)$ is a modified Bessel function. In principle, the foregoing relation permits the prediction of the behavior of the adsorbent bed reacting under non-equilibrium conditions to be made in terms of the rate and equilibrium constants for the system.

The experimental study revealed a dependence of k, upon bed depth not predicted by theory, although otherwise a good correspondence was found. The foregoing equations were found to be applicable also to the description of the desorption of trace amounts of the alkali metal cations by dilute acids.

MDDC - 1114 The Concentration of Isotopes of Potassium by a Counter-Current Electro-Migration Method, National Bureau of Standards, 138 p., n.d., decl. 6/28/46.

This report consists of six papers, numbered MDDC - 1114-A through MDDC - 1114-F. These papers are individually abstracted below:

MDDC - 1114-A Part I. A General Discussion of the Method for the Concentration of Potassium Isotopes, by A. K. Brewer and S. L. Madorsky, 22 p., n.d., decl. 6/28/46.

A counter-current reflux mechanism has recently been developed at the National Bureau of Standards which unquestionably exstablishes a difference in the forward transport velocities of isotopic ions of potassium. The basic principle of this method rests on an imposed flow of electrolyte through a packed column or capillary in the cathode to anode direction at a rate just sufficient to reduce the net forward transport of K^+ ions to zero. Under these conditions, the faster moving $^{39}K^+$ ions will make headway against the electrolyte stream while the slower moving $^{41}K^+$ ions are carried back. This results in a concentration of ^{39}K being built up in the cathode compartment.

The concentrations that can be built up by this method are limited only by the number of theoretical plates that can be realized in the packing. The conditions that must be observed in order to obtain a short H.T.U. are essentially the same as in any conventional reflux column.

The experimental set-up used in the separation of ^{39}K and ^{41}K is illustrated.

MDDC - 1114-B Part II. Experimental Development of the Method for the Concentration of ^{39}K, by S. L. Madorsky and A. K. Brewer, 58 p., n.d., decl. 6/28/46.

The successful operation of an electro-migration cell depends primarily on (1) suitable cell design and packing, (2) suitable electrolyte, and (3) proper means for maintaining a balance between the ion transport and the electrolyte stream flow. While MDDC - 1114-A develops the general theory of electromigration, this paper describes a series of initial experiments designed to study the principal conditions for concentration of ^{39}K in an electromigration cell.

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The data presented in this paper show the feasibility of concentrating ^{39}K by the electro-migration method. Packings made of fine sand proved to be superior to those made of fritted glass, glass wool, asbestos or glass capillary tubes. Concentration of the electrolyte in the electrode compartments remained practically constant through the entire operation of the cells. Experiment 3, which was carried out in a long tube packed with sand, gave the highest and longest sustained value of ϵ -1. This is explained on the ground that the long packing held any losses of ^{39}K from the cathode compartment caused by irregularities in operation such as variation in rates of addition of restituents, loosening of the packing, also, by diffusion. The value of ϵ -1 0.0029, obtained by taking into consideration the ^{39}K concentrate in the packing, at the end of Experiment 3, should be taken as the best value for the experiments described in this paper.

MDDC - 1114-C Part III. A Detailed Investigation of the Method, by A. K. Brewer, S. L. Madorsky, J. K. Taylor, and V. H. Dibeler, 23 p., n.d., decl. 6/28/46.

In view of the success attained in concentrating ^{39}K described in MDDC-1114-B, a detailed investigation was initiated to test the various contributing factors described in MDDC-1114-A. The results of some 170 experiments run under controlled operating conditions are summarized.

MDDC - 1114-D Part IV. Concentration of ^{41}K, by J. K. Taylor and V. H. Dibeler, 9 p., n.d., decl. 6/28/46.

A slight modification of the apparatus and method used in the separation of ^{39}K can be utilized for the concentration of ^{41}K. In this case a stationary boundary is set up at the anode side of the packing. In an arrangement of this type the more mobile ^{39}K ions migrate toward the cathode while the ^{41}K ions accumulate in the anode compartment between the packing and the boundary.

MDDC - 1114-E Part V. Distribution of ^{39}K in the Packing, by J. K. Taylor, V. H. Dibeler, and A. K. Brewer, 8 p., n.d., decl. 6/28/46.

In MDDC-1114-A it was pointed out that an ideal column packed with 100 mesh granules could be expected to give from 100 to 200 theoretical units per centimeter when operating at equilibrium under total reflux and the various factors which affect the H.T.U. were discussed.

In practice, it is possible to determine the H.T.U. of a reflux column from a knowledge of the distribution of the enriched material in the packing. A method for measuring this distribution was described in MDDC-1114-B. A more precise sampling technique, however, had to be worked out for the short packing experiments reported in MDDC-1114-C. Two sampling procedures were developed. The first involved the rapid freezing of the electrolyte in the packing with as little disturbance as possible. The material in various portions of the packing was then removed and analysed. The second, devised by Professor R. G. VanName of Yale University, consisted of placing rubber tips at various positions along the barrel of the tube which could be punctured by a hypodermic needle.

In the first method the electrolyte of the cell was frozen by placing the vessel in a bath of dry ice and acetone. After the electrolyte had solidified, the glass envelope surrounding the packing was broken away to expose the packing as a solid plug. This plug was then sawed into thin disks using a clean hack saw blade. The thickness of each disk, as well as the distance from its center to the cathode end of the packing, was measured as accurately as possible.

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It is necessary to minimize flow of electrolyte from the cathode to the anode compartments during the freezing procedure. The method adopted was as follows: All clamps holding the apparatus in the bath were loosened while the electrolysis was still in progress. At the moment the current was shut off, a pipette was inserted in the cathode compartment and the liquid level was adjusted as closely as possible to that in the anode compartment. The cell was immediately removed from the bath and placed in the freezing mixture. Some disturbance of the electrolyte in the packing undoubtedly took place during this process.

MDDC - 1114-F Part VI. Mass Spectrometric Analysis of Isotope Abundance Ratios, by P. Bradt, O. L. Parham, and A. K. Brewer, 18 p., n.d., decl. 6/28/46.

The mass spectrometer used in measuring the isotope abundance ratios has been described previously by A. K. Brewer. A number of minor changes were made in the present work, the most conspicuous being the substitution of power packs for B batteries as a source of high potential. This, however, resulted in no improvement in the operation of the instrument.

The ion source was of the thermionic type. The positive ions were emitted from a platinum disk impregnated with the sample. The disk, 2 mm in diameter, was spot-welded to a hairpin tungsten filament and was mounted from 6 to 8 mm above the entrance slit to the analysing chamber. Accelerating potentials from 500 to 600 volts were used.

While any potassium containing material can be used to impregnate the platinum disks, crystallin salts like potassium chloride and potassium sulfate are difficult to use since the coatings are inclined to jump off during the initial heating. To overcome this difficulty, it has been found advantageous to convert such salts to phosphates.

The character of the regulation was critically influenced by the shape of the cathode compartment and the placement of the cathode, of the pH electrode and of the injector, as well as the rate of acid injection. The time required for the injected acid to mix completely through the cathode solution was determined by the compartment shape, the placement of the cathode and the rate of hydrogen evolution through its mixing action.

Several potassium sulfate and potassium chloride cells were maintained in self-regulated operation for periods of, in some cases, more than 800 hours. Representative experiments are included in the tabulation in MDDC - 1114-C. The automatic control was of principal value in making the operation of cells more convenient and reliable by eliminating their need for continual attention. From available data the separation efficiency of a cell was in no case impaired upon its conversion to self-regulation.

MDDC - 1115 A Metastable State of Around 10^{-16} Seconds in Re^{187}, by F. K. McGowan and S. DeBenedetti, 4 p., December 3, 1946. (See Physical Review, Vol 71 p. 380, March 15, 1947).

Using the delayed coincidence technique it was found that a short lived excited state of Re^{187} follows some of the β disintegrations of W^{187}. The half-life of Re^{187*} is of the order of one microsecond.

MDDC - 1116 Report No. EC-2, Dated from March 24, 1943 to November 5, 1943, Contained in the Engineer's Log Book, by W. L. Grube, 61 p., November 6, 1943.

This report consists of day by day experimental data reported in Engineer's Log Book, Electro-Chemistry Department, supporting Report No. EC-11, MDDC - 1118 dated November 15, 1944 by W. L. Grube, Research Laboratories Division, General Motors Corporation.

MDDC - 1117 Report No. EC-3, dated from November 6, 1943 to December 31, 1943 Contained in Engineer's Log Book, by W. L. Grube, 61 p., January 3, 1944.

This report consists of day by day experimental data reported in Engineer's Log Book, Electro-Chemistry Department, supporting Report No. EC-11 dated November 15, 1944, by W. L. Grube, Research Laboratories Division, General Motors Corporation.

MDDC - 1118 Report No. EC-11, I. Standard Threshold Tests. II. Program for Establishing the "Bent Cathode Test" as a Means of Determining Impurities in Nickel Planting Baths, by W. L. Grube, 26 p., September 15, 1944.

The standard threshold test has been applied to five electrolytes of the cupric ammonium carbonate class, to one of the acid copper sulfate class, and to one of the alkaline copper sulfate class. These electrolytes have been designated by numbers as follows: No. 6 - cupric ammonium carbonate; No. 7 - same as No. 6 with addition of ammonium sulfate - 20 gms/liter; No. 8 - same as No. 6 with addition of ammonium chloride - 5 gms/liter; No. 9 - same as No. 6 with addition of ammonium chloride - 20 gms/liter; No. 10 - same as No. 6 with addition of ammonium chloride - 80 gms/liter; No. 11 - acid copper sulfate; No. 112G - alkaline copper sulfate.

In that all of the electrolytes tested showed a greater attack on copper than on nickel, those in which there occurred the least dissolution of nickel and the greatest dissolution of copper are considered the most desirable. A measure of this property of the electrolyte is given by the magnitude of the copper to nickel weight-loss ratio, R_1.

All of the electrolytes, with the exceptions of No. 11 and No. 112G, exhibited high values of R_1 when there was no current applied. Electrolytes No. 6 and No. 7 continued to show high values of R_1 when the metals were connected anodically and R_1 for solution No. 112G increased manyfold under this condition.

No. 7 shows the most desirable characteristics in that R_1 is high and attack on the nickel low under all conditions of testing. If current is to be used, electrolyte No. 112G is worthy of consideration. Maximum values of R_1 for this solution are not as high as those of No. 7 but the values in general are more consistent under various conditions. No harmful films formed on the surfaces of the metal during any of the tests in either of the above mentioned solutions.

The results obtained from No. 6 were very similar to those of No. 7 with the exception that the magnitude of R_1 is smaller.

Electrolytes Nos. 8, 9, and 10 show high nickel attack, low R_1, and polarization when current is applied. No. 11 is a poor electrolyte for this purpose in that all values of R_1 are small and dissolution of the nickel is rapid.

A program is included for the development of a standard "Bent Cathode Test" for the control of impurities in electrolytes for plating nickel.

MDDC - 1119 Mass Spectrographic Assignment of Activities to Re^{186} and Re^{188}, by D. C. Hess, Jr., R. J. Hayden, and M. G. Inghram, 1 p., May 26, 1947. (ANL-AJD-172). (See Physical Review, Vol. 72, p. 730, October 15, 1947.)

The document is reproduced here in its entirety.

A sample of ammonium perrhenate solution was bombarded in the Argonne heavy water pile to produce the 18 and 90 hour activities summarized by Seaborg. In order to verify the assignment of the activities to certain isotopes the activated material was analyzed by a mass spectrograph.

A portion of the activated solution was placed in a tungsten crucible and evaporated to dryness. This crucible was then placed in the source system of the mass spectrograph where it was heated and the emergent vapor ionized by electron bombardment. By operation of the spectrograph the ions were separated according to mass and deposited on a photographic plate.

Before development, two successive radioautographs were made from this plate, the first for 36 hours and the second for 180 hours. The plate was then developed to provide mass markers. Development of the transfer plates showed weak lines at masses 186 and 188 on the first plate. On the second plate only the line at 186 was observed, showing that the activity causing the exposure at 188 had a shorter half-life than that causing the exposure at 186.

A second portion of the original irradiated sample was followed by counting it concurrently with the production of the radioactographs. This showed the presence of 18 and 90 hour half-lives. Therefore, the 18 hour half-life is assigned to mass 188, and the 90 hour assigned to mass 186.

In order to determine which isotope of rhenium is responsible for the resonance absorption for neutrons of 2.3 volts energy, two additional samples of ammonium perrhenate were bombarded, one inside an aluminum cylinder with negligible neutron absorption and the other inside a cadmium cylinder of thickness such that the 0.18 volt cadmium resonant neutrons were reduced to less than 0.1% of the initial flux, while the flux of neutrons of 2.3 volt energy was reduced to 88% of the initial flux. By counting the resulting activity it was found that the ratio of initial activities of 18 hour half-life to 90 hour half-life was about 7 for the sample which had been bombarded in aluminum, and 2.5 for that in cadmium. The ratio of the number of activated atoms is thus 1.4:1 for aluminum shielding, and 0.5:1 for cadmium shielding.

MDDC - 1120 Properties of Radioactive Lithium, by D. J. Hughes, D. Hall, C. Eggler, and E. Goldfarb, 5 p., April 10, 1947. (See also Physical Review, Vol. 72, p. 646-647, October 1, 1947.)

Using the deuterium moderated pile, Li^8 having a half-life of 0.89 ± .02 seconds was produced.

Experiments are described which show quite definitely that activity is Li^8 formed by the $Li^7(n,\gamma)$ reaction.

MDDC - 1121 Nuclear Isomerism in Dysprosium 165, by M. G. Inghram, A. E. Shaw, D. C. Hess, Jr., and R. J. Hayden, 3 p., May 6, 1947. (ANL-AJD-169). (See also Physical Review, Vol. 72, p. 515, September 15, 1947.)

The 1.25 min K-converted gamma dysprosium activity produced by slow neutron irradiation of dysprosium was first reported by Flammersfeld. He concluded that this activity was probably due to an

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excited state of dysprosium 163. In order to obtain a direct mass assignment of this activity, dysprosium isotopes, which had been separated with a Dempster-type mass spectrograph employing a high intensity thermal ion source, were irradiated. The usual photographic plate was replaced by a thin beryllium sheet upon which the isotopes were collected. The separate isotopes showed as visible deposits on the beryllium sheet which was then cut into strips, each of which contained only one isotope. The strips were then individually irradiated for two minutes with slow neutrons in the Argonne heavy water pile after which the induced activities were followed with a thin window Geiger-Muller counter. Only the Dy^{164} strip showed appreciable activity above that due to impurities in the beryllium. The activity in other cases is due to the beryllium backing of the deposits. The upper solid curve shows the decay of the Dy^{164} activity. The lower solid curve is representative of the decay at all other mass positions. In the case of Dy^{164}, the induced activity was larger by a factor of 15 than that induced in any other isotope. This activity can be resolved into 1.25 minute and 2.6 hour components. The 2.6 hour activity was previously shown by a different technique to be due to Dy^{165}. The present result shows that both the 1.25 minute and the 2.6 hour activities are produced by neutron irradiation of Dy^{164} and since the ratio of 1.25 minute to 2.6 hour activities was the same with and without cadmium shielding, the short-lived activity must also have been induced by the slow neutrons in the pile. Thus the 1.25 minute activity must have been formed by an (n,γ) reaction on Dy^{164}, and thus be isomeric with the 2.6 hour activity.

The energy level diagram for these activities is shown. Decay curves of activated dysprosium, corrected for the variation of counter efficiency with energy, show that the cross sections for formation of the 1.25 minute and 2.6 hour activities are approximately equal. It appears probable that only the higher excited state of Dy^{165} is formed directly in the (n,γ) reaction of Dy^{164}. If this is the case, the growth of the 2.6 hour activity after a very short bombardment should be observed. Flammersfeld looked for but did not observe this growth.

MDDC - 1122 The Concentration of Stable Isotopes by the Electromagnetic Method, by C. P. Keim, 11 p., n.d., decl. 5/21/47. (CPK-e-10). (See also Chemical and Engineering News, Vol. 25, p. 2624-2625, 1947.)

Since December 1945, experimental electromagnetic equipment at Clinton Engineer Works has been used for concentrating the stable isotopes of lithium, carbon, magnesium, silicon, chlorine, potassium, calcium, titanium, chromium, iron, nickel, copper, zinc, germanium, selenium, bromine, strontium, zirconium, molybdenum, silver, cadmium, indium, tin, antimony, tellurium, and lead. The per cent concentration is given for each of the collected isotopes of lithium, potassium, chromium, iron, nickel, and copper. Complete analytical data is given for chromium, in which the per cent concentrations of all the chromium isotopes as collected in each of the pockets is given. It is likely that 40 to 50 elements which have a total of at least 180 stable isotopes can be separated. Most of the 26 elements and 111 stable isotopes which have been concentrated are being investigated by those who wish to study their nuclear properties. The plan for the future is to study the electromagnetic process as it is adapted to these widely variant mass separations, and to investigate the separation of all stable isotopes in quantities sufficient for research.

MDDC - 1123 Potentiometric Titration of Uranium with Ferric Sulfate, by G. J. Nessle, et al., 2 p., n.d., decl. 5/29/47. (H-WRG-16-1).

The complete document is reproduced here.

Measurement of the titre between the two end points indicated by changes in potential of a platinum-calomel electrode system during addition of ferric ion to a solution originally containing trivalent and quadrivalent uranium affords an accurate method for determination of uranium.

Reduction is accomplished by passage of the uranium in acid solution at room temperature through a Jones reductor. The titration is best performed by addition of 0.1 N ferric sulfate in 5% sulfuric acid solution to 0.3 to 0.5 g of reduced uranium in 225 ml of 5% sulfuric acid solution maintained at 92 ± 2°C under an inert atmosphere. A more reproducible first end point is obtained after addition of chromic ion to the solution of reduced uranium before titration.

Nitrate, fluoride, and large amounts of phosphate interfere with this titration. Iron, chromium, nickel, cadmium, manganese, and aluminum do not interfere but molybdenum, tungsten, copper, and tin must be absent. The interference of vanadium is stoichiometric and may be corrected after separate determination of this element. Titanium introduces a third end point but no error results if all three are detected.

Titrations which are accurate within ± 0.1% may be made in twenty to thirty minutes.

MDDC - 1124 X-Ray Spectrum of Element 43, by W. F. Peed, B. G. Saunders, and L. E. Burkhart, 15 p., January 8, 1947. (See Physical Review, Vol. 73, p. 347-349, February 15, 1948.)

The sample of material submitted to this laboratory by Clinton Laboratories is shown by the X-ray spectrograph to be chiefly element 43. The lines of element 43 measured $K\alpha_1$, $K\alpha_2$, $K\beta_1$, and $K\beta_2$. The agreement of the observed wave length assignment and calculated values are presented in table form.

The chemical and physical history of the material together with the controlled conditions in obtaining the X-ray spectra is conclusive evidence that this material is element 43.

MDDC - 1125 On the Division of Nuclear Charge in Fission, by R. D. Present, 25 p., January 13, 1947. (See Physical Review, Vol. 72, p. 7-15, July 1, 1947.)

The division of nuclear charge in fission depends on the extent to which the proton and neutron densities and spatial distributions are altered during the fission process. In this report the actual division of charge is calculated for the final configuration of spheres in contact on the basis of a general nuclear model in which the charge distribution in the nucleus is non-uniform. The tendency of the protons to spread outward results in the smaller fragment of an asymmetric fission having a greater proton-neutron ratio than the larger fragment. In the most probable division (mass ratio 2:3) the most probable partners (of odd mass number) should both have chain lengths* equal to 3.6. In the case of a 1:2 mass ratio, the probable chain lengths of the light and heavy partners should be 2.5 and 4.1, respectively. Data on the independent fraction yields of particular chain members are found to lie near a smooth (error) curve when plotted with the aid of the theoretical results.

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*In the paper the number, θ, of β-decays of a fragment of given mass and most probable charge for that mass is referred to as a unit of chain length.

MDDC - 1126 A Report on the Design and Some Construction Details of Two Laboratory Vacuum Furnaces for Casting Metals, by E. D. Selmanoff, 29 p., June 29, 1946. (LADC - 279).

The designs of two laboratory furnaces for vacuum casting metals are described in detail. The first furnace employs a tungsten or molybdenum resistance winding. The furnace is constructed in two parts, an upper brass cylindrical "can" containing the heating coil, resting on a similar lower can in which the mold is placed. Bottom pouring technique is employed in both furnaces. The second furnace uses high-frequency induction heating, but may be adapted for resistance heating. It consists of an open-ended silica tube resting on a brass cylindrical can. The induction coil fits around the silica tube and the crucible stands inside the tube. The mold is accommodated by the brass can. In both furnaces temperatures in the neighborhood of 1500 degrees C at pressures of 10^{-3} to 10^{-5} mm Hg have been obtained. The designs of a vacuum gate valve, and compression gland are also given.

A bibliography is appended.

MDDC - 1127 Plutonium(IV) Sulfate Tetrahydrate and Basic Sulfate, by H. H. Anderson, 7 p., n.d., decl. 7/23/47. (ANL-JJK-14B-47);

Plutonium(IV) sulfate crystallizes from aqueous solutions as the tetrahydrate, $Pu(SO_4)_2.4H_2O$; the color varies from a very light coral-pink to a light reddish-brown. Most preparations are a reddish-pink; the smaller crystals are always lighter in color. The solubility of the tetrahydrate is reduced severely by presence of any of the following: alkali sulfates, free sulfuric acid, methanol, and ethanol; mixtures of excess sulfate ion and alcohol produce very low solubilities indeed.

A basic plutonium(IV) sulfate has been isolated from a plutonium solution of low free acidity; the light grey-green solid has been formulated as $Pu_2O(SO_4)_3.8H_2O$ on the basis of the ratio of plutonium to sulfate, plus the fact that it is not very soluble in 1 N acid although easily soluble in 8 N acid.

No evidence of existence of an acid plutonium sulfate has ever been encountered in a variety of preparations, including crystallizations from solutions high in free sulfuric acid.

Solubilities, analyses, and general evidence are given in detail. Two dehydrations of $Pu(SO_4)_2.4H_2O$ resulted in weight changes in keeping with the existence of a lower hydrate, $Pu(SO_4)_2.1/3H_2O$; there was no evidence of anhydrous sulfate, $Pu(SO_4)_2$, in either experiment.

MDDC - 1128 Cesium, Rubidium and Ammonium Plutonium(III) Sulfate Hydrates, by H. H. Anderson, 5 p., n.d., decl. 7/23/47. (ANL-JJK-14B-52).

In contrast to the relatively simple system of plutonium(IV) sulfates previously investigated by the author, it is now evident that plutonium(III) and sulfate give rise to a number of different double salts or complex salts. This present paper describes the compounds obtained in the presence of alkali ions of large atomic radii, cesium, rubidium and ammonium ions.

When the ratio of alkali to plutonium is between eight and five to one the only product obtained with any one of the three, cesium, rubidium or ammonium ions, fits the general type formula $RPu(SO_4)_2.4H_2O$. Chemical analyses justify formulation of the compounds as cesium plutonium(III) disulfate tetrahydrate,

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$CsPu(SO_4)_2.4H_2O$, (mono) rubidium plutonium(III) disulfate tetrahydrate, $RbPu(SO_4)_2.4H_2O$, and finally ammonium plutonium(III) disulfate tetrahydrate, $NHPu(SO_4)_2.4H_2O$. These compounds are similar in formula to ammonium cerous sulfate, $(NH_4)_2SO_4.CE_2(SO_4)_3.8H_2O$ or $NH_4Ce(SO_4)_2.4H_2O$ and related lanthanum and samarium derivatives, $NH_4La(SO_4)_2.4H_2O$ and $NH_4Sm(SO_4)_2.4H_2O$.

More complicated derivatives of the general types $R_3Ce(SO_4)_3$ and $R_5Ce(SO_4)_4$ exist in the rare earths. In plutonium chemistry the existence of $R_5Pu(SO_4)_4$ has been substantiated with potassium and thallous ions, to be described in later papers of the series. However, the type $R_3Pu(SO_4)_3$ has not been found yet.

Solubilities have been measured, cesium forming the least soluble derivative as could be expected. Colors of the rubidium and cesium preparations were light lavender-blue, whereas the ammonium derivative was a more intense light blue.

MDDC - 1129 Dicesium Plutonium(IV) Hexachloride and Related Compounds, by H. H. Anderson, 5 p., n.d., decl. 7/23/47. (ANL-JJK-14B-54).

This research has yielded a series of four light-yellow crystalline derivatives of hexachloroplutonium (IV) acid, H_2PuCl_6, as follows: (di)cesium hexachloroplutonite, Cs_2PuCl_6; (di) tetramethylammonium hexachloroplutonite, $(CH_3)_4N\ _2PuCl_6$; (di) pyridinium hexachloroplutonite, $(C_5H_5NH)_2PuCl_6$; and also (di) quinolinium hexachloroplutonite, $(C_9H_7NH)_2PuCl_6$. All formulas have been established by chemical analysis; and Dr. W. H. Zachariasen has found the hexagonal structure present in Cs_2PuCl_6, although the structure does not agree exactly with any previously known eompounds of a quadrivalent element.

On the basis of the above four hexachloroplutonites, the formula H_2PuCl_6 is assigned to the complex quadrivalent plutonium compound present in 3-6 N hydrochloric acid. Undoubtedly the remarkable stability of hexachloroplutonous acid is a major factor in preventing reduction of plutonium to the tervalent state by the chloride ion.

No double salts could be isolated with potassium, rubidium or zinc chlorides; aniline was oxidized by plutonium(IV) with formation of a dark violet organic dye.

MDDC - 1130 Plutonyl Fluorides, Plutonium Iodates, by H. H. Anderson, 6 p., n.d., decl. 7/23/47. (ANL-JJK-14B-55).

Quinolinium plutonyl trifluoride monohydrate, $C_9H_7NH(PuO_2)F_3\ H_2O$, has been isolated from solution in the form of bright, medium pink crystals. It is nearly twice as soluble in water as the analogous uranyl salt. Related tetramethylammonium, pyridinium, cesium, rubidium and potassium derivatives were more soluble and apparently less stable.

Plutonyl fluoride, $PuO_2F_2.xH_2O$, is a white gelatinous precipitate from a mixture of methanol and concentrated hydrofluoric acid; plutonyl fluoride solutions have a pink-to-rose color.

Plutonium(IV) and fluoride in the presence of certain divalent metals, Cu, Mn, and Co, give only the simple fluoride, $PuF_4.2\ 1/2H_2O$, instead of $CuPu_2F_{10}$, which could be expected by analogy with ceric ion. Moreover, plutonium(III) and fluoride in the presence of rubidium produce only PuF_3, instead of $RbPuF_4$.

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Plutonium(III) and potassium iodate solution precipitate a tan solid of low solubility, shown by chemical analysis to be $Pu(IO_3)_3$. Plutonium(VI) and potassium iodate yield a white precipitate of moderate solubility, in which the ratio of iodate to plutonium is 8 to 1, probably of the type $PuO_2(IO_3)_2.6KIO_3$.

Plutonium(IV), nickel and nitrate furnished crystals with a ratio of $Pu:NO_3:H_2O$ of 1:4.6:7.4, which contained no nickel; this indicates a $Pu(NO_3)_4.8H_2O$ or a higher hydrate, perhaps even a dodecahydrate, $.12H_2O$.

Cesium, plutonium(III) and chloride give no precipitate; if $CsPuCl_4$ exists it must be very soluble.

MDDC - 1131 The Effect of X-Rays on the Activity of Enzymes, by E. S. G. Barron, S. R. Dickman, T. P. Singer, and J. A. Muntz, 48 p., August 1946. (CH-3806).

Moderate amounts of X-rays produce inhibition of enzymes requiring the presence of -SH groups for activity. This inhibition is due to oxidation of the -SH groups to the inactive disulfide as shown by enzyme reactivation with glutathione. Inhibition and reactivation were performed on phosphoglyceraldehyde dehydrogenase, adenosinetriphosphatase, and succinoxidase.

Besides this oxidation of -Sh groups, X-rays have been shown to irreversibly inhibit the activity of enzymes. This inhibition has been attributed to protein denaturation.

A number of crystalline enzymes - trypsin, catalase, lactic dehydrogenase, ribonuclease, - when tested under the conditions of our experiments (with the enzyme, the rate-limiting step in the reaction) were not inhibited by moderate amounts of X-rays. However, inhibition was produced on diminishing the amount of enzyme. These inhibitions are produced by nonspecific protein denaturation produced by large amounts of irradiation.

A bibliography is appended.

MDDC - 1132 Analytical Chemistry of the Manhattan Project. Chapter XXV. Lithium, Sodium, Potassium, Rubidium, and Cesium, by L. G. Bassett and W. Byerley, 20 p., n.d., decl. 7/23/47.

Before considering the individual methods of determination of the alkali metals it should be mentioned that in Project research it has often been necessary to separate the group from large quantities of uranium. This has been accomplished by various methods, such as precipitation of the uranium with 8-hydroxyquinoline, use of peroxide, double precipitation with ammonium hydroxide, the use of 1-nitroso-2-naphthol followed by amyl alcohol extraction and ammonium hydroxide precipitation, precipitation of the uranium with hydrogen peroxide followed by tannic acid-aniline extraction, electrolytic reduction in the presence of fluoride ion, and extraction of the uranium (IV) as the chloroform-soluble cupferrate. The last three separation methods have been used preceding spectrographic determination.

Gravimetric methods for sodium used on the Project have been based on precipitation with magnesium uranyl acetate as described by Caley and Foulk, or with zinc uranyl acetate as described by Barber and Kolthoff.

In a colorimetric method used in England the sodium zinc uranyl acetate is dissolved in hot water and sulphosalicylic acid is used to develop the color caused by the uranium content of the salt.

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Of the three methods most generally used for the precipitation of potassium (as the perchlorate, cobaltinitrite, or chloroplatinate), the cobaltinitrite or chloroplatinate can be used for an indirect colorimetric method of determination. It has been said that the cobaltinitrite is the more variable in composition of the two and hence less suitable for an indirect method.

The objection to the use of cobaltinitrite because of the variability in composition of the precipitate has been overcome by using silver cobaltinitrite in place of sodium cobaltinitrite.

The interest in chemical determination of lithium, rubidium, and cesium has been of a minor nature since spectrographic methods have proved adequate.

Potassium, rubidium, and cesium are similar in their properties to the extent that most methods for the determination of potassium can also be used for the determination of rubidium and cesium.

MDDC - 1133 Note on the Determination of Lead in Pitchblende, by T. R. Braddock, G. L. Martin, and J. R. McCoy, 6 p., July 1946.

The volumetric dichromate method for the determination of lead was selected from among several methods investigated as being best suited for a rapid determination of lead in pitchblende. The method is accurate to within 1% and it does not require the application of an empirical factor.

In this method lead is precipitated with an excess of potassium dichromate, the lead chromate is filtered off, and the excess potassium dichromate is titrated with ferrous sulfate.

MDDC - 1134 Standardization of Ceric Sulfate Solutions with U_3O_8, by R. W. Bragdon and G. L. Martin, 6 p., July 1946.

A procedure is described for the standardization of ceric sulfate solution with purified black oxide of uranium, U_3O_8 (standard sample , 99.95% U_3O_8). When ceric sulfate is standardized with purified U_3O_8 the effect of weighing errors is decreased and a greater accuracy is generally obtained than in the standardization with arsenious oxide. In addition, the use of ammonium persulfate effects a saving of time over the normal practice of dissolving the U_3O_8 in nitric acid.

MDDC - 1135 Preparation of Plutonium Ferrocyanide, M. Cefola, 1 p., n.d., decl. 7/23/47. (ANL-JJK-14B-50).

The complete document is reproduced here.

Early investigations on precipitation reactions of plutonium revealed an insoluble ferrocyanide. About 0.4 microliters of potassium ferrocyanide solution (nearly saturated) was added to 0.2 microliters of 0.002 M plutonium(IV) nitrate - 1 M nitric acid solution in a capillary cone. Immediately a precipitate formed which appeared under the microscope to be green when viewed in reflected light. After equilibrating the washed precipitate with water for a few hours, the concentration of plutonium in solution was about 10 mg/1. The precipitate did not dissolve at a detectable rate in 6 M hydrochloric acid, but it was readily soluble in concentrated hydrochloric acid. The possibility that the precipitation had been due to an iron impurity was excluded as a portion of the same plutonium(IV) nitrate solution gave no red color upon addition of potassium thiocyanate.

MDDC - 1136 Determination of Trace Amounts of Elements by Radioactivation Analysis, by H. M. Clark and R. T. Overman, 1 p., n.d., decl. 7/14/47.

This document is an abstract and is reproduced here in its entirety.

As the facilities for producing artificial radioactivity become more numerous, there should be a steady increase in the application of activation analysis to the routine determination of trace amounts of elements. The method can be applied to the determination of many elements, several of which are difficult to determine by the usual methods. When intense sources of bombarding particles are used to produce the radioactivity, the method is capable of unusually high sensitivity.

The principles ans limitations of the method are discussed with particular emphasis on activation by neutron bombardment. Examples are given to illustrate the method and recommendations are made for techniques, procedures and standards. Included is a list of some of the elements having radiation characteristics which make them particularly suited to determination by this method.

MDDC - 1137 Four Photographs Illustrating Production of Radioactive Materials at Clinton Laboratories, by Clinton Laboratories, 4 p., n.d., decl. 7/11/47.

The photographs illustrate the following:

(1) An apparatus for separating radiocarbon from calcium nitrate which has been bombarded in the chain-reacting pile.

(2) View as seen through a periscope inside a "hot" cell showing complex equipment necessary for chemically processing highly radioactive materials behind a thick concrete wall.

(3) High pressure equipment for chemically separating radioactive phosphorus from sulfur which has been irradiated in the pile.

(4) Apparatus for separating radioactive carbon from calcium nitrate which has been bombarded in the chain-reacting pile.

MDDC - 1138 The Theory of Isotope Separation, by K. Cohen, 177 p., n.d., decl.

The studies given are a selection from a larger volume of material and here consists of the following chapters: I, III, and IV.

Chapter I treats the cascade theory. Certain generalities which are common to many different separation methods are collected.

Chapter III treats the centrifugal method.

Chapter IV is composed of reactions outlining briefly two-phase separations (including chemical exchange and distillation), the thermal diffusion method, and some remarks on the separation of deuterium.

A number of tables, graphs, and diagrams are included.

A bibliography of relevant reports is appended.

MDDC - 1139 Fluorination with Antimony Pentafluoride, by L. R. Evans, 152 p., October 1945.

This document is a thesis.

One of the specific problems was the development of a method for the preparation of n-C_7F_{16} with the use of a minimum amount of elemental fluorine.

One method which was used to prepare C_7F_{16} may be represented by the following series of unbalanced equations:

Step 1 - $C_7H_{16} + Cl_2 - C_7H_xCl_{12} + HCl$ (1)

Step 2 - $C_7H_xCl_{12} + HF/SbCl_5 - C_7H_xCl_6F_6 + HCl$ + antimony salts (2)

Step 3 - $C_7H_xCl_6F_6 + SbF_5 - C_7H_2Cl_2F_{10} + SbF_3Cl_2$ (3)

Step 4 - $C_7H_2Cl_2F_{10} + AgF_2 - C_7ClF_{15} + AgF + Cl_2 + HF$ (4)

Step 5 - $C_7Cl_2F_{14} + SbF_5 - C_7ClF_{15}$ + antimony salts (5)

MDDC - 1140 The Toxicity and Metabolism of Plutonium in Laboratory Animals, by R. D. Finkle, et al., 197 p., August 1946. (CH-3783).

The preparation and administration of the injected plutonium offered no Chemical or biological challenge except the added care that was necessary in working with radioactive materials.

The analytical methods in this type of an experiment assumed a certain magnitude of importance, and, in this respect, new schemes and methods of analysis had to be developed. In most cases, the tissues were dry-ashed by muffling for 48 hours at 550 C after a definite drying period, or were wet-ashed by treatment with fuming nitric and hydrogen peroxide. The LaF_3 method of assay for product in tissue was used quite extensively though, in some cases, a straight LaF_3 precipitation on a solution of tissue ash was found to be unsatisfactory because CaF_2 and possibly other substances also precipitate and add to the self-absorption so that accurate assay is difficult. The alternate method that seems satisfactory, although somewhat more time-consuming, consists of a preliminary precipitation of zirconyl phosphate from acid solution; this is redissolved and a LaF_3 precipitation is carried out to bring down the activity in form suitable for counting.

Fecal and urine excretion were analyzed by the same methods, though in many cases, expecially in the urine, with much less success.

The overall analytical recovery on experimental animals ranged from 70 to 100 per cent with an average of 88 per cent. The results tended to be low and much of the blame was laid to urine and feces in their absorption on cage bottoms, and upon poor methods of analysis.

Hematological studies of the peripheral blood made on mice, rats, and rabbits after the I.V., I.M., or intracardial injection of plutonium in the plus 6 or plus 4 nitrate or plus 6 citrate states indicate the following:

On the basis of hematological effect, no apparent species, strain, or sex differences in sensitivity to plutonium appears to exist.

Intracardial, I.V., or I.M. injection of plutonium:

(a) Doses of 0.0003 or 0.0006 μc/g of plutonium caused no detectable hematological alteration in the peripheral blood of mice, rats, and rabbits during 300 days of observation.

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(b) A dose in the range of 0.003 μc/g produced a minimum to moderate depression of the leucocytes and platelets in all three species within the first 100 days.

(c) A dose of 0.0063 μc/g produced a moderate to severe and sustained leucopenia in all species studied and caused an anemia and early death in mice and rats (135 days).

(d) Doses of 0.0156 to 0.125 μc/g produced correspondingly more severe and sustained anemia, leucopenia, reticulocyte reduction, and platelet deficiency; and early death in mice and rats.

Plutonium intoxication produced morphological changes in the nucleated cells of the peripheral blood comparable to those which occur after exposure to external radiations.

A macrocytic anemia developed in rats following the parenteral administration of plutonium in doses between 0.0063 and 0.063 μc/g. This effect was less significant in mice and rabbits after comparable doses.

A bibliography of 48 references is appended.

MDDC - 1141 Mass Spectrographic Analysis of Solids, By W. M. Garrison, 42 p., November 15, 1945. (CP - 3452).

The purpose of this investigation was to evalute the Chicago mass spectrograph as an analytical instrument for solids.

The spark source is discussed in relation to general requirements,the nature of spark excitation and plate calibration.

Relative element abundance measurements with the spark source were made. Metallic alloy systems were studied and the results obtained on Cu-Sn and Pb-Sn are reported to indicate the methods of analysis. The precision of the analyses was 5-10 per cent. Mixtures of oxides were studied and the relative precision of the analysis was ~30-50 per cent. Anhydrous chlorides gave a precision of ~10 per cent.

An attempt was made to use the spark source in determining the isotopic composition of product. These results indicated the loss factor for product oxide was $\sim 10^8$ and would require a prohibitive amount of sample for an isotope distribution measurement.

A description of a redesigned instrument is given and a photograph is included. This should make possible the study of the mass assignments of the fission product elements.

MDDC - 1142 Metabolism of Fission Products, Progress Report for Month Ending March 15, 1943, by J. G. Hamilton, 19 p., n.d., decl. 7/14/47.

This report is made up of a series of papers numbered MDDC-1142-A through MDDC-1142-E. These papers are individually abstracted below:

MDDC - 1142-A Radio Lanthanum (La^{140}), by R Overstreet, L. Jacobson, K. Scott, and H. Fisher, 11 p., n.d., decl. 7/14/47.

Preparation of Radio Lanthanum without Carrier--A satisfactory method for the preparation of La^{140} has been successfully developed. The twelve day Ba^{140} has been separated from fission products with the use of inert Ba as a carrier. Following the preparation and purification of the Ba^{140} the radio lanthanum was separated from the former using ferric hydroxide as carrier. The iron was subsequently removed by extraction with iso-propyl ether. Decay curves have been measured on La^{140} samples thus separated and the half-life found to be 40.9 hours. No detectable long-lived tail was observed in samples followed over as long an interval as seven half-lives. This indicates that there was present less than 1% of any long-life impurities such as radio barium or radioctive rare earths. The half value thickness for the beta-rays using Al absorbers was found to be 86 milligrams per square centimeter.

Tracer Studies--The distribution of La^{140} following intraperitoneal and intramuscular injection was followed for a period of eight days. A significant proportion of the injected material remained unabsorbed by both routes of administration. The liver and skeleton were found to show the highest accumulation of this element. The uptake per gram of tissue in the liver was considerably higher than in the case of Y^{86}. The uptake by the bone per gram of weight was significantly less in the case of La^{140}. However, the La^{140} was accumulated in the bone and was firmly fixed in this organ. No significant absorption took place by way of the digestive tract. When La^{140} was introduced directly into the lungs it was found that a large proportion was firmly fixed in this structure.

MDDC - 1142-B Radio Cerium ($Ce^{>140}$), by R. Overstreet, L. Jacobson, K. Scott, and H. Fisher, 1 p., n.d., decl. 7/14/47.

Preparation without Carrier--Radio cerium has been prepared from a uranium fission mixture without the use of Ce carrier. Thorium was used as a carrier and the thorium and cerium finally separated from one another by iodate precipitation. The identity of the purified radio cerium without carrier was demonstrated by the following procedure:

1. Chemical identification with the use of inert Ce as a carrier upon an aliquot fraction of the final purified solution.
2. Confirmation of the presence of short-lived praeseodymium daughter which was deseribed by Spedding.
3. Beta-ray absorption curves were found to be comparable to those published in various reports of the chemistry group.

Tracer Studies--A large group of animals have been injected with $Ce^{>140}$ (including some unknown activities by intraperitoneal and intramuscular injection without carrier. A sufficient number have been injected so that they may be sacrificed in groups of three extending from one day period to the sixty-four day period. In addition some animals have received $Ce^{>140}$ by stomach tube. Preliminary results, which include, the one, four, eight, and sixteen day period, reveal that $Ce^{>140}$ is handled in a manner very similar to that observed with La^{140}. No significant absorption occurs by way of the digestive tract. Considerable retention by the lungs was noted when the radio cerium was administered directly into this organ. A full report will follow.

MDDC - 1142-C Unseparated Fission Products, by R. Overstreet and L. Jacobson, 1 p., n.d., decl. 7/14/47.

Preparation of a New Sample without Carrier--Eighteen pounds of uranyl nitrate has received 10,000 microampere hours of beryllium neutrons. The bombarded material was then extracted repeatedly with ether to remove the uranyl nitrate and the fission products separated without the addition of carrier. This separated mixture now contains less than five milligrams of uranium in a total of eight millicuries of activity. An assay of the different fission products is being completed.

MDDC - 1142-D Radio Strontium (Sr^{85}), by I. L. Chaikoff, M. C. Fishler, and C. Entnman, 1 p., n.d., decl. 7/14/47.

Tracer Studies--A continuation of this work with more complete data indicates that the retention of Sr^{85} by the skeleton was essentially as has been described in a previous report. The uptake of this material in the bones of the animals which received it by mouth was found to rise by almost a factor of two between the fourth and sixteenth days. Otherwise, there were no significant differences to be observed between the present more complete information and that which was given previously. The rate of excretion of Sr^{85} has now been followed for a period of thirty days, and after the fifteenth day its excretion is apparently less than the rate of decay of that which is retained in the body.

MDDC - 1142-E A Preliminary Study of the Removal of Radio Strontium (Sr^{85}) from the Body, by D. M. Greenberg and N. Kaplan, 5 p., n.d., decl. 7/14/47.

Preliminary experiments on removal of Sr^{85} from rats has indicated that sodium citrate, parathyroid hormone, ammonium chloride, and strontium chloride all apparently slightly enhance the removal of Sr^{85}. Massive doses of irradiated ergosterol has no such effect. This study must be repeated upon a much larger group of animals at varying periods after Sr^{85} administration before any quantitative apprisals as to the relative effect of these different agents may be made.

MDDC - 1143 Metabolism of Fission Products, Progress Report for Period Ending February 15, 1943, by J. G. Hamilton, 37 p., n.d., decl. 7/15/47. (CH - 498).

This report consists of a series of papers numbered MDDC-1143-A through MDDC-1143-E. These papers are individually abstracted below:

MDDC - 1143-A Radio Yttrium (Y^{86}), by K. Scott, 9 p., n.d., decl. 7/15/47.

Extended experiments covering a period of sixty-four days revealed that approximately 50% of Y^{86} introduced into the peritoneal cavity is deposited in the bones. No significant decrease of this deposition was observed between the first and sixty-fourth day. The rate of elimination of Y^{86} was extremely slow after the first few days of administration. The daily rate of elimination after the first week is negligible as compared to the rate of radioactive decay of this radio element. The oral

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administration of Y^{86} indicates that the total absorption of this element from the digestive tract is less than .1%.

When Y^{86} is introduced as a solution of YCl_3 directly into the lungs apparently a large proportion of the administered material remains unabsorbed in this organ at four days. The proportion that underwent absorption was distributed in the tissues in a manner similar to the localization after intraperitoneal injection.

MDDC - 1143-B Radio Strontium (Sr^{85}), by I. L. Chaikoff, M. C. Fishler, and C. Entnman, 8 p., n.d., decl. 7/15/47.

Incomplete experiments with Sr^{85} indicate that the intraperitoneal injection of this element is followed by the prompt deposition of approximately 75% of the dose in the bones. The soft tissues contain negligible quantities of Sr^{85} as compared to the skeleton. The oral administration of Sr^{85} was followed by an uptake of approximately 10% of the administered dose at the end of twenty-four hours. The relative distribution of that which was absorbed was almost identical to the values observed after intraperitoneal injection.

MDDC - 1143-C Unseparated Fission Products, by R. Overstreet, L. Jacobson, and K. Scott, 8 p., n.d., decl. 7/15/47.

A procedure has been devised for the separation of raw fission products without carriers from neutron-irradiated uranyl nitrate. An analysis of the final separated material which had been completely freed from uranium gave a distribution which was quite similar to the values noted by Coryell and Seaborg.

The intraperitoneal injection of this material in small group of rats sacrificed at four and sixteen days after injection revealed the skeleton to be the single most important organ for retention of this material. At four days approximately one third of the administered dose was in the bones and this value was found to be slightly higher at the end of sixteen days. High values for retention were observed in the liver and spleen of the four day interval. By the sixteenth day, however, these levels fell considerably. The over all picture of excretion indicated that the rate of elimination was rather slow although somewhat more rapid than in the case of yttrium. Four days after oral administration only 1.6% of the administered dose was absorbed and almost all of this was found in the skeleton. This observation suggests the possibility that a very large proportion of the absorbed fission material was strontium.

MDDC - 1143-D Radio Zirconium (Zr^{89}), by R. Overstreet, et al., 5 p., n.d., decl. 7/15/47.

A satisfactory method has been developed for the preparation in the pure state of Zr^{89} as $ZrOCl_2$ without the presence of carrier. When administered by intraperitoneal and subcutaneous injection approximately 80% at two and six day intervals appear to remain at the site of injection. No marked degree of specific localization was noted in any of the tissues examined.

MDDC - 1143-E Proposed Procedure for Study of Removal of Long Life Fission Products from the Body, by D. M. Greenberg, 3 p., n.d., decl. 7/15/47.

A group of proposed procedures for the study of removal of long life fission products from the body has been compiled. Measures which have been tried and have a considerable measure of success are: acid or alkali administration associated with a low calcuim diet; parathyroid hormone administration; high potency vitamin D; citric acid administration; displacement with non-radioactive isotopes.

MDDC - 1144 The Fluorination of Polychloropolyfluorohydrocarbons by Silver Difluoride and Cobalt Trifluoride, by B. W. Hotten, 191 p., June 1945.

This document is a thesis.

The use of the reagents, silver difluoride and cobalt trifluoride, for the fluorination of partially fluorinated and chlorinated hydrocarbons to perhalogenated products which contain a large percentage of fluorine and a small percentage of chlorine is described. The more important variables which affect this reaction are discussed for the conversion of normal heptene derivatives having the average formula, $C_7H_2Cl_2F_{10}$ into products having the average formula, C_7ClF_{15}. A number of reactions involving similar derivatives of pentane octane, toluene, and xylene are described. Several physical properties are listed for the products which were obtained.

MDDC - 1145 Some Excitation Functions of Alphas and Deuterons on Bi, by E. L. Kelly and E. Segrè, 4 p., June 18, 1947. (BP - 80).

The abstrac of this document has previously been issued as MDDC - 1008 and listed in this journal.

MDDC - 1146 The Application of Ion-Exchange to the Separation of Yttrium Group Rare Earths, by B. H. Ketelle, 1 p., n.d., decl. 7/18/47.

This document is an abstract and is reproduced here in its entirety.

In order to study the radioactive properties of the rare earths, materials of high purity are required and rapid separations of adjacent rare earths are desirable. Previously untested predictions of ion-exchange column theory have been investigated in an effort to make a complete and rapid separation of small quantities of rare earths. Preliminary investigations established that at the relatively high flow rates, one to two $ml/cm^2/min$, which can be used at elevated temperatures with exchange columns of very fine mesh adsorbent extremely good separation of milligram quantities of the rare earths was obtained.

The separation of all the rare earths has been demonstrated on a 97 cm by 0.26 cm^2 column of 270/325 mesh Dowex-50 resin operated at 100°C. The pH of the 4.75% citric acid used was 3.2 for the heavy earths and 3.4 for the light earths. A continuous record of the amount of rare earth being desorbed was obtained on a recording beta counter. Between the desorption peaks for the several earths the activity decreased to the background activity of the instrument. Because its ionic radius is almost the same as that of holmium, yttrium is desorbed between holmium and dysprosium in column separations. As a result of the small difference in radii the separation of holmium, yttrium, and dysprosium is even more difficult to accomplish than is the separation of the heavier rare earths.

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The application of the ion-exchange column for quantitative determination of rare earth impurities has been demonstrated on a sample of erbium which had previously been purified on another column. The analysis indicated that this erbium contained 10 p.p.m of thulium.

MDDC - 1147 Complex Ions of Plutonium, VII. The Fluoride Complex Ions of Plutonium(IV), by C.K. McLane, 19 p., n.d., decl. 7/23/47. (ANL-WMM-159).

Measurements of absorption spectra and of the emf of the Pu(III) Pu(IV) couple in HF solutions of plutonium are given. These clearly indicate the existence of a monofluoride comples of tetravalent plutonium (PuF^{+++}). Further complex formation in more concentrated fluoride solutions is also indicated. Calculation of the dissociation constant of the monofluoride complex from absorption spectra and emf measurements are given.

A bibliography is included.

MDDC - 1148 The Chemical Identification of Isotopes of Nd and Element 61, by J. A. Marinsky and L. E. Glendenin, 1 p., n.d., decl.

This document is an abstract and is reproduced here in its entirety.

The vastly improved separation of rare earths elements afforded by the recently developed ion exchange method (using organic resins) has led to the positive chemical identification of four radioactive isotopes of Nd and element 61 from fission and slow neutron bombardment of Nd. The rare earth elements are adsorbed on a column of the ion exchange resin and eluted with a complexing reagent (5% citrate solution at pH 3). Experiments show that the order of elution of the rare earths is the reverse of that of atomic number and that atomic number can be determined from elution curves.

The radioisotopes identified by this technique are: 11d Nd^{147}, 1.7h $Nd^{(149)}$, 3.7y element 61^{147}, and 47h element 61^{149}. A discussion of the chemical identification, decay characteristics, genetic relationships, fission yields, and mass assignments is presented.

MDDC - 1149 Preparation of Certain Polychloropolyfluorohydrocarbons, by R. C. Schreyer, 108 p., June 1946.

This document is a thesis.

Some of the compounds synthesized were perfluoroheptane, perfluorodimethylcyclohexanes, and hexafluoroxylenes. The perfluoro compounds had been prepared directly from the hydrocarbon and elemental fluorine but processes for the preparation of these compounds were desired which required little or no elemental fluorine.

The following unbalanced equations outline a process developed at Purdue for the preparation of perfluoroheptane.

(1) $\underline{n}C_7H_{16} + Cl_2 \rightarrow C_7H_xCl_{12} + HCl$

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(2) $C_7H_xCl_{12} + HF + SbCl_5 + C_7H_xCl_6F_6$ + antimony salts

(3) $C_7H_xCl_6F_6 + SbF_5 - C_7H_xCl_2F_{10}$ + antimony salts

(4) $C_7H_xCl_2F_{10} + AgF_2$ or $CoF_3 - C_7F_{16} + C_7ClF_{15} + C_7Cl_2F_{14} + AgF$ or $CoF_2 + HF + Cl_2$

(5) $C_7ClF_{15} + C_7Cl_2F_{14} + SbF_5 - C_7F_{16} + C_7ClF_{15}$ + antimony salts

Each of these reactions is designated as Step I, Step II, etc., of the process. Further research and development on the process eliminated Steps III and V by the discovery that the antimony salts of Step II could be used as a modified Step III reagent and that monochloroperfluoroheptanes and dichloroperfluoroheptanes have properties very similar to perfluoroheptane.

The author is concerned primarily with the conditions for the replacement of as many chlorine atoms by fluorine atoms per molecule as possible in polychloroheptanes by the use of hydrogen fluoride in the presence of antimony (V) chlorofluorides. The preparation and physical constants of some of the polychloropolyfluorohydrocarbons obtained as degraded material from the process are also considered.

MDDC - 1150 Diffusion of Thermal Neutrons, by A. M. Weinberg, 14 p., n.d., decl. 2/10/47.

Formulas for the diffusion of thermal neutrons are calculated for the following two cases:

I. The neutron energy is unaffected by scattering collisions with the medium. This corresponds to diffusion in a medium of infinite atomic weight; it is a fairly good approximation for thermal neutrons diffusing in U.

II The neutron suffers complete "amnesia" after each collision, that is, its energy after collision is uncorrelated with its energy before a collision, and it is thrown into a Maxwellian energy distribution, regardless of its initial energy. This is more nearly correct for collisions with light nuclei than with heavy ones, but is of course not strictly correct for either.

MDDC - 1151 The Crystal Chemistry of Fluorides of Thorium, Uranium, Neptunium, and Plutonium, by W. H. Zachariasen, 14 p., June 11, 1947. (ANL-FWHZ-116).

This document consists of a set of notes for oral presentation. Information on the studies of more than fifty fluorides of thorium, uranium, neptunium and plutonium is contained, tabulated as follows: Table 1 gives a list of the fluorides which were examined. As shown in Table 2, some of these compounds have crystal structures of previously known types. A number of new structure types have, however, shown up. Because of the small scattering power of fluorine, complete structure determinations could be carried out only for some of the compounds. However, the positions of the heavy metal atoms have been found for all of the compounds listed in Table 1.

Table 3 shows the lattice dimensions of fluorides having previously known structure types. The lattice dimensions of the tetrafluorides illustrate the striking decrease in the size of the ion with increasing atomic number due to the filling of the 5f shell. The corresponding contraction in the trivalent state is demonstrated by the lattice dimensions of the trifluorides. Of considerable interest are the double fluorides of thorium and uranium with barium, lead, strontium or calcium. In the structure there is complete intermixture of tetravalent and divalent cations so that these double fluorides become in effect pseudo-trifluorides.

Similarly, pseudo-difluorides with the fluorite type of structure were encountered in PuOF and in the alpha-forms of K_2ThF_6, K_2UF_6, and Na_2UF_6.

Table 4 gives complete crystal structure data for uranyl fluoride and for the two forms of uranium pentafluoride. Uranyl fluoride is of layer structure type. The uranyl groups have their axes normal to the layers while the fluorine atoms are slightly below and above the uranium planes. All the various preparations of uranyl fluoride which the writer has examined show stacking disorder of the layers. This stacking disorder varies considerably in degree from one sample to the next depending upon the heat treatment of the samples.

In the alpha-UF_5 structure there are strings of UF_6-octahedra parallel to the four-fold symmetry axis with only van der Waals forces holding the strings together. In the beta-UF_5 form on the other hand, each uranium is linked to seven fluorine atoms so that a three-dimensional network of UF_7-polyhedra is obtained. As a consequence the beta-form has more than 10% higher density than the alpha-form.

Table 5 gives the crystal structure data for U_2F_9, $NaTh_2F_9$, and Na_3UF_7. The first two compounds are cubic and isomorphous in spite of the lack of correspondence in their formulas. The heavy metal atoms are structurally equivalent. In U_2F_9 there is resonance between the plus four state and the plus five or plus six states. The sodium atoms in $NaTh_2F_9$ are located in positions corresponding to holes in the U_2F_9 structure. The analogous uranium compound, NaU_2F_9, does not exist.

The tetragonal Na_3UF_7 structure is closely related to that of fluorite. The unit cell corresponds to two fluorite cells placed on top of each other. There is segregation between sodium and uranium atoms and furthermore one in every eight fluorine atoms is removed at random to balance the valences.

As far as the other compounds go only partial structure determinations are as yet available. Table 6 gives a list of the lattice dimensions for the various compounds.

Most of these compounds are phases observed in the systems KF-UF_4, KF-ThF_4, and NaF-UF_4 which the writer has studied in detail. Because of the many phases which occur in these systems it was difficult to prepare single-phase samples, and the identification of the various phases accordingly could not be carried out by the orthodox methods of analytical chemistry.

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The chemical identity was therefore determined in the following unusual way. First the dimensions of the unit cell were deduced. Next with the aid of the observed diffraction intensities the number and positions of the uranium atoms in the unit cell were determined.

Tables 8 and 9 illustrate how this information, together with a knowledge of the space requirements of potassium and fluorine atoms, permits the determination of the chemical formula.

The various unusual compounds referred to in the tables were prepared by different investigators as listed in Table 10.

MDDC - 1152 X-Ray Diffraction Studies of Miscellaneous Uranium Compounds, by W. H. Zachariasen, 7 p., June 1946. (ANL-FWHZ-120).

Lattice dimensions are given for the following compounds: $K_3UO_2F_5$, UCl_6, $UO_3.H_2O$, $UO_4.2H_2O$, K_2UO_4, $BaUO_4$, UF_4, ThF_4, CeF_4 and $UF_4 \cdot 2.5H_2O$. The positions of the heavy metal atoms have been found for most of the compounds.

This paper gives a summary of results of incomplete crystal structure determinations for miscellaneous uranium compounds.

MDDC - 1153 Fluorides of Uranium and Thorium with the LaF_3-Type of Structure, by W. H. Zachariasen, 6 p., June 1946. (ANL-FWHZ-121).

The compounds UF_3, $ThOF_2$, $SrUF_6$, $PbUF_6$, $BaUF_6$, $CaThF_6$, $PbThF_6$ and $BaThF_6$ are shown to have the LaF_3-type of structure.

This paper gives the results of crystal structure studies of a series of fluorides of uranium and thorium all of which have the LaF_3-type of structure. The list of fluorides includes: UF_3, $ThOF_2$, $BaUF_6$, $PbUF_6$, $SrUF_6$, $BaThF_6$, $PbThF_6$, $SrThF_6$ and $CaThF_6$.

MDDC - 1154 Crystal Structure Studies of the Systems NaF-UF_4, NaF-ThF_4, and NaF-LaF_3, by W. H. Zachariasen, 10 p., August 1946. (ANL-FWHZ-123).

In the NaF-UF_4 system the following intermediate phases have been found: $NaUF_5$, α-Na_2UF_6, β-Na_2UF_6, γ-Na_2UF_6 and Na_3UF_7.

$NaLaF_4$ is the only intermediate phase observed in the system NaF-LaF_3.

In the course of an incomplete study of the system NaF-ThF_4 the phases $NaTh_2F_9$, β-Na_2ThF_6, γ-Na_2ThF_6, and Na_4ThF_8 have been observed.

Crystal structure data are given for all of the phases.

MDDC - 1155 Laboratory Production of Enriched BF_3 from $CaF_2 \cdot BF_3$, by R. E. Zedler and R. I. Luman, 5 p., June 13, 1947.

A system for generating BF_3 from $CaF_2 . BF_2$ is described and a diagram of the apparatus is presented.

The BF_3 thus collected should be 97.2% pure, 75% of the impurity being air. Final purification of the BF_3 is done on the system used to evacuate and fill counters. The process is simply that of solidifying the BF_3 in a liquid nitrogen trap in an evacuated system and then re-evacuating the system to remove the non-condensable air impurity from the solidified BF_3.

MDDC - 1156 Absolute Beta Counting Using End-Window Geiger-Müller Counter Tubes, by L. R. Zumwalt, 1 p., n.d., decl. 7/23/47.

This document is an abstract of MDDC - 1346.

An extensive study has been made of the determination of the absolute disintegration rates of beta ray emitting isotopes of maximum energies 0.3 to 2.3 Mev.

Conventional thin mica end-window Geiger-Müller counter tubes with a standard lead housing and source arrangement were calibrated for absolute beta counting. To do this, determinations were made of the "geometry" of the tubes for given source positions by using various sources of known disintegration rate and by the elimination of or the correction for effects due to absorption and scattering of beta particles. The disintegration rate of isotopes used in the calibration were ascertained by one of four methods: (1) coincidence counting technique, (2) carrying of a daughter activity from a known amount of parent, (3) observing the growth of activity of an alpha emitting daughter, or (4) by calorimetric measurement.

Counter tube "geometries" determined by use of isotopes Co^{60}, I^{131}, Au^{198}, RaE, Na^{24}, and UX_2 with correction for absorption and scattering effects, showed a standard deviation of about three per cent and seemed to be substantially independent of beta energy. The "geometries" obtained correspond to geometries calculated from solid angle considerations in the case where the "sensitive volume" of the counter is taken to begin from one to three millimeters in back of the counter window.

MDDC - 1157 Portable Alpha Survey Meter, Mark 1 Model 41A, Argonne National Laboratory, 3 p., n.d., decl. 1/17/47.

This survey meter is designed to detect small amounts of alpha emitting materials contaminating desk-tops, tables, etc. The instrument consists of an air proportional counter probe connected by a cable to a measuring circuit. The probe receives alpha particles over an effective area of 100 sq cm. The whole instrument is carried in a canvas bag hung from the shoulder of the operator.

The operator, in using the instrument, pushes the probe over the contaminated surface and observes the alpha counts as single clicks in head phones or for higher intensities reads on the counting rate meter. For the latter use the instrument has two different sensitivities, the meter full scale corresponding either to 3,000 or 30,000 alpha disintegrations per minute from the contaminated surface. A known alpha source is attached to the circuit box in case it is found necessary to recalibrate the instrument. The probe has about 20% geometry.

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A circuit diagram shows that pulses from the counter probe are amplified and then equalized by a trigger pair. The counting rate meter is in the plate circuit of the second tube of the trigger pair. The high voltage necessary for the proportional counter is supplied by a special battery of 2448 volts tapped at every 25 volts. This battery in service should have almost its shelf life, i.e., about 6 months. Occasionally the shorting plug should be rewired to give higher voltage as the cells deteriorate. The filament battery and 67 1/2 volt B battery should be replaced after about 80 hours operation. Total weight about 14 lbs.

A photograph of the instrument is included.

MDDC - 1158 Lethal Effect of X-Rays on Four Marine Micro-Plankton Organisms, by K. Bonham, A. H. Seymour, L. R. Donaldson, and A. D. Welander, 14 p., n.d., decl. 3/18/47. (See also Science, Vol. 106, p. 245-246, September 12, 1947).

Literature on the effect of X-rays on bacteria, yeasts, and Protista is summarized in a table showing that the average immediately lethal dose is 595,000 roentgens (20,800 to 1,250,000) and that the average dose capable of stopping growth or cell division of these micro-organisms is 93,000 r (12,000 to 400,000). In this experiment vialed samples of Chlorella sp., Nitzschia closterium, a carteriid, and another mastigophoran (unidentified, brown) were each subjected to 5 exposures from 1000 r to 100,000 r. Numbers of organisms per unit volume of culture were counted using ruled blood counting chambers. Immediate immobilization of the brown mastigophoran was 50% effective at 50,000 r, and 100% at 100,000 r. Counts for an organism were comparable only with other counts for different irradiation samples of the same organism on the same date. Counts over a period of 4 months were most nearly as might be expected in the case of Chlorella where the concentration of individuals remained inversely proportional to the amount of irradiation for practically the entire time, except in the case of the 1000 r sample which exceeded one of the two controls. Nitzschia counts in the higher irradiations decreased earlier and more drastically than did those of Chlorella, but later these more heavily irradiated samples gave higher counts than the lower dosages. Counts of the two mastigophora were arranged erratically with only a general tendency for count to be inversely related to exposure. In no case did a sample count drop to and remain at zero.

Graphs are included.

MDDC - 1159 The Synthesis of Phenanthrene-9-C^{14}, by C. J. Collins and W. G. Brown, 13 p., n.d., decl. 7/18/47.

Fluorine was converted to 9-fluorenecarboxylic acid-10-C^{14} by carbonation of 9-fluorenesodium with carbon 14 enriched carbon dioxide. Lithium aluminum hydride reduction of the methyl ester yielded 9-fluorenemethanol-10-C^{14}. Dehydration of 9-fluorenmethanol-10-C^{14} with phosphorous pentoxide was accompanied by a Wagner rearrangement to form the desired phenanthrene-9-C^{14} in overall yields of 55-65%. The synthesis was effected on a 0.5 millimole scale.

MDDC - 1160 **The Metabolism of Fission Products and the Heaviest Elements in Rats and Plants, by J. G. Hamilton, 69 p, June 11, 1947. (BP-90). (See also Radiology, Vol. 49, p. 325-343, 1947).**

An investigation of the assimilation, distribution, rentention, and excretion of the fission products and heaviest elements in the rat has been conducted at the Crocker Radiation Laboratory, University of California, Berkeley, California. These studies were initiated October 15, 1942, and are continuing at the present time. An extensive survey has been made of the metabolism of twenty-one different radioelements. A large number of possible procedures for the treatment of plutonium poisoning have been explored and one method has been developed that may be of practical value. This method considers the feasibility of overlaying plutonium deposits in bone, but further work is necessary to determine whether this procedure will actually decrease its toxicity. The accumulation and rentention of the principle fission products and plutonium in soils and their metabolism in plants have been investigated.

MDDC - 1161 **Alkaline Condensations of Fluorinated Esters and Ketones, by A. L. Henne, M. S. Newman, L. L. Quill, and R. A. Staniforth, 7 p., decl. 12/16/46.**

Ethyl trifluoroacetate was condensed with ethyl acetate to $CF_3COCH_2CO_2Et$, which was isolated as its copper derivative. The latter was decomposed to CF_3COCH_3 by means of 20% H_2SO_4. Similarly CHF_2CO_2Et gave $CHF_2COCH_2CO_2Et$ and CHF_2COCH_3, but it did not condense with itself, nor with CF_3CO_2Et. The alkaline condensation of CF_3CO_2Et and acetone yielded $CF_3COCH_2COCH_3$, while CF_3CO_2Et and CF_3COCH_3 yielded $CF_3COCH_2COCF_3$. All the condensed compounds gave very stable metallic chelates with great ease, and advantage was taken of this property to separate the condensed products from their reaction mixtures.

MDDC - 1162 **The Trochotron: A Crossed Field Type Mass Spectrometer, by J. L. Horton, 28 p., April 7, 1947.**

A study of a relatively large scale mass spectrometer using crossed electric and magnetic fields is discussed. Such a spectrometer has two outstanding features: focusing which is independent of velocity distribution and angular divergence at the ion source, and a linear mass scale giving improved resolution. The construction of the instrument including electric field, ion sources, and collector is described. The possibilities of such an instrument for isotopic analysis and isotope separation are reviewed and isotopic "scans" of silver and barium are included. Some of the problems encountered with the instrument are also discussed.

A photograph of the instrument is included showing the electric field plate-assembly with the voltage divider and the ion source unit.

MDDC - 1163 **Ceramics and Nucleonics, by A. L. Johnson, 9 p., n.d., decl.**

This document is a talk to be presented by the author before the American Ceramic Society.

An account of the part played by the science of ceramics in the development of the atom bomb as carried out by the Department of Substitute Materials Project of the War Department is given, in an effort to indicate research trends in the ceramic field. Extensive research on refractory oxides, nitrides and sulfides has been carried out in order to determine the possible use of these materials in connection with the many problems of the DSM project.

MDDC - 1164 The Exchange Adsorption of Ions from Aqueous Solutions by Organic Zeolites. IV. The Separation of the Yttrium Group Rare Earths, by B. H. Ketelle and G. E. Boyd, 47 p., n.d., decl. 7/15/47. (See also Journal of the American Chemical Society, Vol. 69, p. 2800-2812, November 1947.)

In order to study the radioactive properties of the rare earths, materials of high purity are required and rapid separations of adjacent rare earths are desirable. Previously untested predictions of ion-exchange column theory have been investigated in an effort to make a complete and rapid separation of small quantities of rare earths. Preliminary investigations established that at the relatively high flow rates which can be used at elevated temperatures with exchange columns of very fine mesh adsorbent extremely good separation of milligram quantities of the rare earths was obtained.

The separation of all the rare earths has been demonstrated on a 97 cm by 0.26 cm^2 column of 270/325 mesh Dowex-50 resin operated at 100°C. The pH of the 4.75% citric acid used was 3.2 for the heavy earths and 3.4 for the light earths. Because its ionic radius is almost the same as that of holmium, yttrium is desorbed between holmium and dysprosium in column separations. As a result the separation of holmium, yttrium and dysprosium is even more difficult to accomplish than is the separation of the heavier rare earths.

By the use of the ion-exchange column for quantitative estimation of rare earth impurities, the degree of separation of adjacent heavy rare earths is shown. A sample of erbium which had previously been purified on a column was shown to contain only 10 p.p.m. of thulium.

MDDC - 1165 The Crystal Structure of Zirconium, Oxysulfide, ZrOS, by J. D. McCullough, L. Brewer, and L. A. Bromley, 9 p., n.d., decl. 7/31/47.

The crystal structure of ZrOS has been investigated by means of X-ray powder photographs and by powder spectrometry. The substance has a simple cubic lattice with $a_o = 5.685 \pm 0.002$A with space-group $T^4 - P_{213}$. In the resulting structure Zr shows a coordination number of seven, being surrounded by three sulfur atoms at 2.63 A, one sulfur atom at 2.61 A and three oxygen atoms at 2.13 A. The coordination polyhedron has a point-group symmetry of C_{3v} - 3m.

MDDC - 1166 Use of Redux Adhesives for Bonding Metal, by M. Martin, 3 p., May 20, 1947. (BP-98).

Redux is a thermosetting synethetic resin which is intended for bonding metal to metal and metal to wood.

A brief description is given of the use of "Redux" adhesive in bonding together synchrotron pole-piece laminations so as to produce a vacuum tight joint. Some notes are included on methods of reducing the rate of gas evolution from redux exposed to vacuum.

MDDC - 1167 Determination of Plutonium in Human Feces, by E. Maxwell, R. Fryxell, and W. H. Langham, 11 p., n.d., decl. 8/5/47. (LADC-396). (See also Journal of Biological Chemistry, Vol. 172, p. 185-190, January 1948.)

A detailed description is given of a method for determining plutonium in human feces. The essential features of the method are as follows: The dried sample is ashed in a muffle furnace and the ash dissolved in 4 M HCl. The reduced plutonium is carried from an aliquot of the feces ash solution with calcium oxalate. The calcium oxalate precipitate is digested with fuming NHO_3 and taken up in 4 M HCl. Ferric iron is added and the plutonium is extracted into $CHCl_3$ as the cupferride. The cupferride complex is destroyed with $HClO_4$. The plutonium is carried with LaF_3, slurried to a platinum plate and counted in an alpha counter. Results with both mock and actual human feces ash solutions show the recovery of plutonium by this method to be 80 per cent or better.

MDDC - 1168 C^{14} Tracer Studies in the Rearrangements of Unsymmetrical α-Diketones: Phynylglyoxal to Mandelic Acid, by O. K. Neville and W. G. Brown, 10 p., n.d., decl. 8/7/47.

Mandelic acid, labeled C^{14} in the α-position was obtained from similarly labeled phenylglyoxal on treatment with alkali, thus demonstrating that no rearrangement of the carbon skeleton occurs and consequently that the reaction proceeds by a shift of the aldehydic hydrogen atom.

MDDC - 1169 Decay Scheme of $_{45}Rh^{106}$, by W. C. Peacock, 18 p., n.d., decl. 8/7/47. (See also Physical Review, Vol. 72 p. 1049-1053, Dec. 1, 1947).

The decay scheme of $_{45}Rh^{106}$ (30 s) is proposed as a complex beta spectra with endpoints at 3.55 ± 0.10 Mev. The latter is $18 \pm 2\%$ abundant and followed by two gamma rays 0.51 ± 0.02 and 0.73 ± 0.02 Mev in cascade, or a single 1.25 ± 0.05 Mev gamma. The 1.25 Mev gamma is present in 1-2% of the disintegrations. Evidence to support Gamow-Teller selection rules for beta decay is given.

MDDC - 1170 The Elliott Low Absorber Counter (Figure from Report CC-763), by W. H. Sullivan, 1 p., n.d., decl. 8/8/47.

This document consists of a scaled diagram of the counter. See also MDDC-1171, and MDDC-1172.

MDDC - 1171 A Low Absorption Counter of Improved Design, by W. H. Sullivan, N. R. Sleight, and E. M. Gladrow, 10 p., February 25, 1944. (CC-1380 A-2021).

Beta ray absorption studies of the soft radiations associated with a number of the fission product activities were made possible by the use of a windowless counter of special design. The Ames low absorption counter is similar, in principle, to the Elliott low absorption counter but a number of changes have been made to increase its usefulness. With the new type of counter, the background rate and sensitivity of the counter tube may be checked at any time during the beta ray absorption

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measurements of a given sample. By the use of a smaller counter tube and an increased size of vacuum desiccator, the number of absorbers is increased to 16 which affords greater accuracy of measurement through the low energy region.

Photographs and a detailed description of the apparatus are included.

Further improvements in the counter are described in MDDC-1172.

MDDC - 1172 A Simplified Design for the Ames Windowless Counter, by W. H. Sullivan, 8 p., March 1946. (CC-3458).

Detailed drawings of the counter are presented. The counter is an improved version of the one described in reports MDDC-1170 and MDDC-1171.

The principal improvements in the apparatus are listed as follows: (1) The upper ground glass joint controlling the sample wheel is eliminated. (2) The rubber tubing vacuum seal for the above control is eliminated. These changes reduce the number of possible points of leakage into the evacuated apparatus during filling or operation. (3) An absolute reproducible geometry for both the sample and the instrument standard (U_3O_8) is insured through the use of the aluminum block stops on the bottom plate. (4) A number of minor changes in the details of the parts were made by the Instrument Shop to simplify and expedite their construction.

The instrument is used in beta ray absorption studies of the soft radiations associated with a number of the fission product activities.

MDDC - 1173 Pulse Height Analyzer - Model A, by W. A. Higingotham, 15 p., July 27, 1944. (LADC-220).

The circuit consists of three discriminators, an anti-coincidence circuit, two delay circuits, a shorting circuit on the input, scalers and power supply. It is designed for fast positive pulses corresponding in speed to those from electron collection or proportional counters, and for slow positive pulses from ion collection chambers. One discriminator is set to fire on all pulses that rise an arbitrary amount above noise. The other two determine the upper and lower boundaries of a channel whose width is adjustable from 1.5 to 7.5 volts. The position of this channel is adjustable from 0 to 50 volts. The delay and shorting circuits make the chance of spurious measurements small, even at relatively high counting rates.

Circuit diagrams are included.

MDDC - 1174 Effects of X-Rays on Rabbits. Part II. The Hematological Effects of Total Body X-Irradiation in the Rabbit, by L. O. Jacobson, et al., 45 p., July 1946. (CH-2798).

The hematological constituents of the peripheral blood have been studied in Swift snuffle-free rabbits before and after the administration of acute total body X-irradiation. Doses of 25 r to 800 r were administered and studies made through 96 days in many experiments. From the observations made, the conclusions derived are:

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A significant normochromic anemia develops in groups of rabbits exposed to 500 and 800 r. A significant anemia develops only in individual animals within a group with doses below 500 r. Reticulocyte reduction is significant with doses of 100 r and above.

An initial leucocytosis, significantly greater than controls, occurs within the first 24 hours after doses of 500 r. After 500 r and 800 r, a sharp rise in leucocytes occurs by 12 hours, followed by a decline and another peak of leucocytes at 24 hours. The leucocytosis during this period is due exclusively to an increase in heterophils.

Lymphocytes decrease significantly within 24 hours after exposure to 25 r and above. Reduction is apparent 3 hours after irradiation with 100 r and above, with a minimum value at from 24 to 48 hours. Recovery proceeds slowly. Supravital staining (Janus green and neutral red) reveals an increase in neutral red granules after 200 r and above. Mitochondrial changes are variable. Monocytes decrease initially but return to normal limits or are increased by 4 to 6 days after 200 r and above.

Heterophil values increase initially after 500 and above. No significant reduction was observed with doses of 300 r and below. Doses of 500 r to 800 r inclusive produce a significant depression within 96 hours, with recovery by 23 days or less.

Platelet values are reduced in a manner paralleling the granulocytes.

An "abortive rise" in lymphocytes and heterophils between the 4th and 11th day after X-irradiation characteristically precedes recovery with doses of 200 r and above, respectively.

Morphological changes in erythrocytes, leucocytes, and platelets occur after doses of 100 r and above.

The lymphocyte values of the peripheral blood are the most sensitive known indicator of effect of acute total body X-irradiation.

A bibliography of 59 references is included.

MDDC - 1175 Lecture Series on Nuclear Physics (Lectures 1 - 46), Los Alamos, 363 p., October 1943 to March 1944. (LADC-246). (Reprinted by U.S. Government Printing Office. c/o Superintendent of Documents, .55¢)

This report comprises six series and forty-six papers.

The first series is devoted to Terminology, by E.M. McMillan, with papers on the following: the atom and the nucleus; interaction of light with water; forces holding the nuclei together; reactions between nuclei; radioactivity; β-decay and neutron reactions; nuclear fission.

The second series is entitled Radioactivity, by E. Segre, E. Teller, and F. Bloch, with lectures on the following: the radioactive decay law; the radioactive decay law fluctuations, passage through matter; α-particles and their interaction with matter; the theory of stopping power; interaction of charged particles with matter; interaction of radiation with matter; the properties of nuclei; survey of stable nucleus; theory of alpha disintegration and the theory of beta particles; positron emission and K capture and gamma radiation.

The third series is concerned with Neutron Physics, by J.H. Williams, with lectures on the following: discovery of the neutron; neutron sources and typical reactions for production of neutrons; properties of slow neutrons; fast neutrons; properties of fast neutrons and cross section measurements.

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The fourth series is devoted to the Two Body Problem, by C. L. Critchfield, with lectures on the following: nuclear constants; neutron-proton interaction; spin-spin forces in the deuteron and proton-proton scattering; three body problems; interaction of neutron and proton with fields.

The fifth series is concerned with The Statistical Theory of Nuclear Reactions, by V. F. Weisskopf, with the following lectures: introduction and qualitative treatment; cross sections and emission probabilities; resonance processes; discussion of resonance phenomena; non-resonance processes.

The sixth series is entitled Diffusion Theory, by R. F. Christy, and the following lectures are included: diffusion equations and point source solutions; point source problems and albedo; angular distribution and boundary conditions at a free plane boundary; the slowing down of neutrons; the slowing down of neutrons in water; the Boltzmann equation; correction to diffusion theory.

MDDC - 1176 Testing of a "Dura Seal" Rotary Seal, by T. H. Mauney, 14 p., January 9, 1947.

The Dura Seal is a rotary seal consisting of a Stellite member fastened to a pump shaft and a stationary graphite member which surrounds the shaft and is sealed to the pump housing. The seal to prevent escape of gas from the housing is effected by contact between the ground faces of Stellite and graphite. Normally Dura seals are cooled by circulating water through the graphite member. However, in order to prevent possible dilution of the circulation medium by the coolant, the seal was redesigned for air cooling.

Tests were run to determine the effectiveness of air cooling, the operating characteristics, and the life expectancy for a 5 1/2 inch Dura Seal. It was found that air cooling was satisfactory. The power consumed by the seal was generally less than 1000 watts and the leakage of air through the seal less than 0.002 lbs/sec. The rate of wear on the face of the graphite member varied considerably with conditions; however, it appeared that satisfactory performance can be attained only in an installation where the seal is readily accessible and can be adjusted periodically.

MDDC - 1177 The Use of Perfluoro- and Chloroperfluoro-Olefins in the Synthesis of Fluorocarbon Materials, by W. T. Miller, Jr., 190 p., n.d., decl. 5/27/47.

The following are discussed in detail: the preparation and general properties of perhalogen olefins; synthetic methods involving the use of elementary fluorine; thermal reactions of perfluoro- and perfluorochloro-olefins; the polymerization of perfluoro- and perfluorochloro-olefins; thermal cracking of perhalogen polymers; physical properties of perhalogen polymer materials; summary of quantitative data.

Photographs and diagrams are included.

A bibliography of 16 references is appended.

MDDC - 1178 Preparation of Certain Organic Chloro and Fluoro Compounds, by G. M. Rothrock, 110 p., February 1945.

This document is a thesis and consists of three parts.

Part I. Preparation of the Bis (Trifluoromethyl) Benzenes.

The best yield of bis (trifluoromethyl) benzene was obtained when pure 1,4-bis (trichloromethyl) benzene was used. m-Xylene gave lower yields, and tar formation occurred when o-xylene was fluorinated at the same temperature as used for m- and p-xylene. It is therefore desirable to use xylene from which o-xylene has been removed; the mixture of m- and p-xylene is relatively cheap.

Agitation was necessary if good yields were to be obtained.

If no catalyst was used, the optimum temperature for fluorination of bis (trichloromethyl) benzene with hydrogen fluoride was 150°C.

If either antimony trifluoride or antimony pentachloride was used as a catalyst, the optimum temperature was 100°C.

In the absence of a catalyst, the minimum reaction time was about three hours.

Since antimony trifluoride and antimony pentachloride catalysts reduce the optimum temperature for the reaction, it is probable that these catalysts will also shorten the time required for completion of the reaction.

MDDC - 1178 Preparation of Certain Organic Chloro and Fluoro Compounds, by G. M. Rothrock, 110 p., February 1945.

This document is a thesis and consists of three parts.

Part II. Preparation of Certain Chlorofluoro Derivatives of Ethylbenzene

Ethylbenzene was chlorinated in the presence of light to phenylpentachloroethane and (chlorophenyl) pentachloroethane. The chlorination to phenylpentachloroethane was accomplished in 24 hours at 100°C in the presence of water (to prevent tar formation).

(Chlorophenyl) pentachloroethane was prepared by chlorinating phenylpentachloroethane in the presence of light for an additional 24 hours at 130°C.

Phenylpentachloroethane was chlorinated in the presence of iron or ferric chloride at 140-160°C for 11 hours to give nonachloroethylbenzene.

Nonachloroethylbenzene was fluorinated to pentachlorotetrafluoroethylbenzene and hexachlorotrifluoroethylbenzene. The fluorination was carried out in an autoclave under pressure using hydrogen fluoride and in the presence of antimony pentachloride.

Phenylpentachloroethane was fluorinated at atmospheric pressure or at pressures of 80-100 pounds per square inch with hydrogen fluoride in the presence of antimony pentachloride to give compounds having one, two, and three chlorine atoms replaced by fluorine: $C_6H_5C_2Cl_2F_3$, $C_6H_5C_2Cl_3F_2$, and $C_6H_5C_2Cl_4F$. (Chlorophenyl) pentachloroethane was fluorinated in a similar manner to give compounds having two and three chlorine atoms replaced by fluorine: $C_6H_4ClC_2Cl_2F_3$, and $C_6H_4ClC_2Cl_3F_2$.

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The chlorofluoro derivatives of phenylpentachloroethane and (chlorophenyl) pentachloroethane were chlorinated in the presence of iron to give the perhalo compounds: $C_6Cl_5C_2Cl_2F_3$ and $C_6Cl_5C_2Cl_3F_2$.

It was found that antimony pentafluoride reacts with nonachloroethylbenzene and with the perhaloethylbenzenes by cleaving the side chain from the aromatic nucleus. The principal product isolated with hexachlorobenzene.

Liquid chlorine reacted with ethylbenzene in the presence of light by addition to the aromatic ring. The products contained four and six chlorine atoms per molecule.

MDDC - 1178 Preparation of Certain Organic Chloro and Fluoro Compounds, by G. M. Rothrock, 110 p., February 1945.

This document is a thesis and consists of three parts.

Part III. Chlorination and Fluorination of n-Hexadecane

n-Hexadecane was chlorinated photochemically to a material with average composition of about $C_{16}H_{14}Cl_{20}$.

Material with an average composition of about $C_{16}H_{14}Cl_{20}$ was fluorinated with hydrogen fluoride and antimony pentachloride in an inert solvent to give a brown viscous liquid boiling 180-260°C at 3 mm pressure. The identity of this material was not definitely established. Chlorine and fluorine analyses seem to indicate that some dehydrohalogenation occurred. The average composition of the product appears to be about $C_{16}H_{12}Cl_{11}F_7$.

Antimony pentafluoride appears to be too reactive for use in fluorinating polychlorohexadecane.

MDDC - 1179 Specifications for the Type 961B Scaler, by E. Wakefield, 9 p., September 1944. (CP-2107).

Because of a need for additional scalers fifty of the modified Columbia design were ordered from Offner Electronics Inc. As the chasses were already punched and assembly was fairly well along, a circuit slightly different from the Type 961A Scaler, as tested and recommended to TNX, was utilized. Specifications for Type 961B Scaler were arrived at by a series of conferences in which the circuit components were based on past experiences. The complete circuit has not been tested.

From Type 961A Scaler, described in Engineering Group Report No. SC50206, CP-2114, there have been but four major circuit changes as shown in an accompanying drawing No. SC10207.

1. The amplifier input jack has been eliminated.
2. The time relay circuit has also been eliminated.
3. An .02 f 1250 v condenser in parallel with a 220,000 ohm 1 watt resistor has been placed in parallel with the recorder.
4. High voltage is across the 1LN5 tube.

MDDC - 1180 Pocket Radiation Alarm, by P. R. Bell, 11 p., n.d., decl. 8/12/47.

A circuit diagram and photographs of a personal radiation alarm small enough to be carried in a pocket are presented.

The shielding effect of the batteries make it necessary to carry the instrument in the pocket in such a position that the chamber side of the instrument is away from the body. A belt clip is attached to make this automatic.

The weight of the instrument is 386 grams and it measures 1 3/8 x 2 1/4 x 5 3/4 inches.

The instrument operates satisfactorily at a sensitivity of 11 mr of gamma rays. Less sensitivity is achieved by cementing a small lucite block onto the chamber wall. This lucite block must be coated wi... graphite to make it conducting.

MDDC - 1181 Vibrational Spectrum and Thermodynamic Properties of Uranium Hexafluoride Gas, by J. Bigeleisen, M. G. Mayer, P. C. Stevenson, and J. Turkevich, 12 p., n.d., decl. 8/12/47.

The Raman spectra of liquid UF_6 and of UF_6 dissolved in C_7F_{16} have been photographed. Three Raman lines are found for UF_6 at 200, 511, and 656 cm^{-1}. The infrared spectrum of the gas has been obtained in the region between 2 and 17 μ.

A vibrational assignment of all the fundamental frequencies is made on the basis of the regular octahedral model. The calculated infrared active overtones are in good agreement with experiment. Using 2.0 A as the U-F distance from electron diffraction measurements, the entropy, heat capacity and - (F° - E°/T) are calculated from 100°K to 1000°K for the gas. The calculated entropy and gas heat capacity are in good agreement with experiment.

MDDC - 1182 Synthesis of C^{14} Labeled Organic Compounds, by M. Calvin and B. Tolbert, 7 p., July 9, 1947. (BC-65).

This report consists primarily of charts which constitute a progress report on the C^{14} work going on in the Bio-Organic Division of the Radiation Laboratory, University of California, Berkeley.

In general only high yield procedures have been used, except in a few cases, namely the preparation of tyrosine, dibenzanthracene, and dihydroxyphenylalanine. All procedures have been done on a 15 to 25 millimole scale. This is large enough to give adequate amounts of material for later biological experiments, and yet small enough to give adequate specific activities. In smaller samples the problems of surface tensions, volatility of compounds, transfer of solids, and filtrations become increasingly important. For most biological experiments a minimum specific activity of 10^6d min/mg of compound has been found satisfactory.

A bibliography of eight references is included.

MDDC - 1183 On the Interaction between Neutrons and Electrons, by E. Fermi and L. Marshall, 24 p., June 1947. (See also Physical Review, Vol. 72, p. 1139-1146, December 15, 1947).

The possible existence of a potential interaction between neutron and electron has been investigated by examining the asymmetry of thermal neutron scattering from xenon. It has been found that the scattering in the center of gravity system shows exceedingly little asymmetry. Assuming an interaction of a range equal to the classical electron radius, the depth of the potential well has been found to be -300 ± 5000 ev. This result is compared with estimates based on the mesotron theory according to which the depth should be 12000 ev. It is concluded that the interaction is not larger than that expected from the mesotron theory, that however no definite contradiction of the mesotron theory can be drawn at present, partly due to the possibility that the experimental error may have been underestimated, and partly due to the indefiniteness of the theories which makes the theoretical estimate uncertain.

MDDC - 1184 The Transmission of Slow Neutrons through Microcrystalline Materials, by E. Fermi, W. J. Sturm, and R. G. Sachs, 14 p., n.d., decl. 1/13/47. (See also Physical Review, Vol. 71, p. 589-594, May 1, 1947.)

The transmission of monochromatic slow neutrons through microcrystalline Be and BeO has been determined. The source of neutrons was the Argonne heavy water pile. These neutrons were monochromatized by means of a mechanical velocity selector for low energies and a neutron crystal spectrometer for higher energies. The results are in excellent agreement with the theory of elastic scattering from crystals. It is found by comparison of the results on BeO with the theory that the scattering amplitudes of Be and O have the same sign. This method may be used to determine the relative scattering phases of other pairs of nuclei which can be combined to form a crystalline material. The sample must consist of crystals smaller than a micron in linear dimensions. Other possible sources of disagreement between theory and experiment are discussed.

The following are appended: a microcrystalline beryllium cross section; a scattering cross section of BeO.

MDDC - 1185 A New Dominant Autosomal Mutant Affecting Coat Color in the Mouse, Mus musculus, by A. B. Grobman and D. R. Charles, 9 p., August 16, 1946. (II-188-7078).

A new recessive mutant, producing situs inversus viscerum, is reported in the mouse.

Among the offspring of a mating, Little dba ♂ by C57 Black ♀, was one female of coat color quite similar to the phenotype of ddB- although this constitution was not expected since C57 ♀ was presumed homozygous for D. Twenty-six Siblings of the exceptional female were intense colored (D-).

This female carried a mutant gene for which the authors propose the name, White, symbol, Wh. Mice heterozygous for Wh. resemble, but are somewhat lighter than, dilute, dd, mice. WhWh animals are indistinguishable by color from true albinos, cc. The results of various crosses involving Wh are summarized in a table.

On a black, B-, background, the descending order of color intensity among animals with combinations of white, Wh, and dilute, d, is: D-whwh, black; ddwhwh, dark gray or "blue"; D-Whwh, gray; ddWhwh, pastel gray; --WhWh, white. The seriation is similar in bb. Brown mice with the constitution ddWhwh are a very delicate silver color and appear lighter than the corresponding blacks.

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To express the effects of Wh in more concrete fashion, individual heirs were mounted and studied.

The measurements (expressed in per cent) so obtained from 87 hairs involving about a dozen mice are summarized. The higher the number is, the greater the amount, or the dispersion, of the pigment in the hair, consequently, the darker is the color. This technique is not sufficient to permit accurate identification of hairs since there is a great deal of overlapping of values. Other factors aid, however. For example, Wh reduces or restricts medullary pigment in a more regular fashion than does d. With a little practice one is able to distinguish between browns and blacks under the microscope. If hairs are removed from the same general areas from mice of like ages and a comparative approach is used, a key, which contains additional information, should prove to be an accurate aid in the identification of mice in the classes considered.

Whwh mice darken slightly with age. The original female, B-Whwh, though, was quite distinguishable from black, B-whwh, at the age of 338 days. The rate of darkening is somewhat greater in dilute than in White mice.

It is not easy to distinguish dilute and Whwh mice by coat color alone. The pigmentation of the extremities is, however, different. In such White mice the feet and tail are light which is not the case with dilute.

In addition to reduced pigmentation of the coat and extremities, the eyes are affected; they tend to be very dark ruby (rather than black) in B-D-Whwh mice; they are definitely red in B-ddWhwh animals; and they are pink and pigmentless in ----WhWh individuals.

In several sublines a white ventral spot is present. In the lines in which these are most extensively developed an occasional white mark is found on the dorsum.

Homozygous white mice have been compared with Swiss-Bagg albinos; they differ in two respects. The White mice are smaller than the albinos. When taken out of a dark pen into a well lighted room the eyes of the Whites seem to be relatively smaller than those of the albinos. Whether this is due to squinting or an actual difference in the size of the eyeball is uncertain.

The gene, Wh, is also accompanied by decreased fertility.

The segration of the alleles of White seem to be independent of sex.

MDDC - 1186 The 4n + 1 Radioactive Series: The Decay Products of U^{233}, by F. Hagemann, et al., 1 p., n.d., decl. 7/15/47. (See Physical Review, Vol. 72, p. 252, August 1, 1947.)

The decay products of U^{233}, which constitute a substantial fraction of the entire missing 4n + 1 radioactive series, are listed together with their radioactive properties in the following table:

Isotope	Type of Radiation	Half-Life	Energy of Radiation (Mev)
$_{90}Th^{229}$	α	7×10^3 yr	4.85
$_{88}Ra^{225}$	β-	14.8 days	0.2
$_{89}Ac^{225}$	α	10.0 days	5.80
$_{87}Fa^{221}$	α	4.8 min	6.30
$_{85}At^{217}$	α	0.018 sec	7.00

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$_{83}Bi^{213}$	β-(96%)	47 min	1.2 (β-)
	α (4%)		6.0 (α)
$_{84}Po^{213}$	α	very short	8.30
($_{81}Tl^{209}$)	(β-)	?	?
$_{82}Pb^{209}$	β-	3.3 hr	0.7
$_{83}Bi^{209}$	stable		

Neptunium (4n + 1) is suggested as a name for the series.

MDDC - 1187 Interaction of Neutrons with Electrons in Lead, by W. W. Havens, Jr., I. I. Rabi, and L. J. Rainwater, 9 p., June 20, 1947. (M-2272). (See Physical Review, Vol. 72, p. 634-636, October 1, 1947.)

Dee's estimate of the upper limit for the neutron electron interaction could be greatly reduced by considering the interaction of slow neutrons with atoms. These considerations can be greatly extended by considering the interference of the wave scattered by the nucleus with the wave scattered by all of the electrons in the atom in connection with the magnetic scattering of neutrons.

To study this effect, the total cross section of solid and molten lead as a function of the wave length of the incident neutrons was measured using the neutron spectrometer. The experimental points are given. References are indicated and results are plotted.

MDDC - 1188 A Discussion of the Transpiration Method for Determining Vapor Pressure, by J. V. Lepore and J. R. Van Wazer, 20 p., n.d., decl. 8/8/47.

Using the concepts of the kinetic theory of gases, a mathematical discussion of the transpiration method of measuring vapor pressure is given. It is suggested that extrapolation to zero carrier gas velocity of the deposition rate of the material being studied be used to compute the vapor pressure of the material. The heat and activation energy of vaporization (or sublimation) can be obtained from the variation with temperature of the curve relating rate of deposition to rate of carrier gas flow.

MDDC - 1189 The Deuteron Problem with Gaussian Potentials, by S. Moszkowski and R. G. Sachs, 5 p., June 1947. (See also Physical Review, Vol. 73, p. 184-185, Jan. 15, 1948).

The complete text of the document is reproduced below:

As a preparatory step for a calculation of the triton binding energy, the constants have been determined for a Gaussian neutron-proton potential including a tensor interaction. The calculation was performed by means of the variation method. Both the S and D wave functions were assumed to be Gauss functions and the variation was carried out with respect to the ranges of each of these functions and with respect

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to the relative coefficient of the S and D terms. The variation was subject to the condition that the quadripole moment have the experimental value $Q = 2.73 \times 10^{-27}$ cm^2. In this way the depth of the potential and the relative strength of the ordinary and tensor potentials were determined as a function of the range of the interaction.

Explicitly, the form of the interaction was assumed to be

$$V = \left\{1 + \frac{3}{\sqrt{8}}\gamma\left[\frac{(\sigma_1 \cdot r)(\sigma_2 \cdot r)}{r^2}\right] - \frac{1}{3}(\sigma_1 \cdot \sigma_2)\right\} J(r)$$

where

$$J(r) = -J_0 e^{-r^2/\alpha^2}$$

The S wave function was taken to be

$$\Psi_S = c_S e^{-\lambda r^2/2}$$

and the D function to be of the form

$$\Psi_D = c_D \frac{3\mu}{\sqrt{8}}\left[(\sigma_1 \cdot r)(\sigma_2 \cdot r) - \frac{1}{3}(\sigma_1 \cdot \sigma_2)\right] e^{-\mu r^2/2}.$$

The total energy calculated for the wave function $\Psi = \Psi_S + \Psi_D$ was then varied with respect to λ, μ, and c_D/c_S. The minimum binding energy was then a function of J_0, γ, and α. J_0 and γ were then determined as a function of α by setting the binding energy equal to 2.17 Mev and the quadripole moment equal to the value given above.

The values of J_0/ϵ, γ, $\alpha_0^2\lambda$, $\alpha_0^2\mu$, and the D state probability are given on the accompanying figures as functions of α/α_0 where ϵ is the binding energy of the deuteron and α_0 is 2.80×10^{-13} cm. The calculation was not carried out for $\alpha/\alpha_0 < 1$ because, then, the D state probability becomes sufficiently large to increase considerably the amount of work required to obtain a result. It is usually assumed that $\alpha/\alpha = 1$. In this case, $J_0 = 21.7$ Mev, $\gamma = 1.50$, $\alpha_0^2\mu = 2.92$, $\alpha_0^2\lambda = 0.92$ and the D state probability is 4.0%.

MDDC - 1190 Cobalt 62 Radioactivity, by T. J. Parmley and B. J. Moyer, 2 p., June 9, 1947. (BP-89).

The complete document is reproduced below.

A sample of nickel enriched in isotope 52 was subjected to fast neutron bombardment, which was produced by deuterons impinging on a beryllium target in the Crocker Laboratory's 60-inch cyclotron. In these experiments the samples were surrounded by 35 mils of cadmium to minimize a n, α reaction. Among other activities was one having a $13.9 \pm .2$ minutes half life. Chemistry was employed in which a cobalt fraction was separated from the residue with the new activity appearing in the cobalt fraction.

A similar activation of nickel 61 did not reveal any activity shorter than the 1.75 hour half life of cobalt 61, even though a n, p,n, reaction should produce cobalt 60 which has a 10.7 minute half life. This means that under the conditions of the experiment the neutron bombardment of nickel 61 must be a n,p reaction. Furthermore, since the 13.9 minute activity appeared only in the cobalt fraction from the activated nickel 62 this must also be a n,p reaction with the production of radioactive cobalt 62.

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Absorption data were taken using aluminum and lead absorbers placed directly above the nickel 62 sample. Alternate readings were made without absorbers above the sample, both to correct readings to a common standard and, also, to be sure that the data were being taken while the activity was definitely present. Furthermore, absorption measurements were repeated after the 13.9 minute half life activity had become imperceptible, to be sure that the data were those from cobalt 62.

Aluminum absorbers gave a value of 1200 milligrams per square centimeter necessary to reach the end-point of the beta spectrum corresponding to 2.5 ± 0.1 Mev beta minus.

A gamma radiation present was measured dropping to half value after passing through 12,000 milligrams per square centimeter of lead. This corresponds to 1.3 ± 0.1 Mev gamma rays. The system was calibrated for gamma rays by means of cobalt 60 which emits two gamma rays of energies 1.1 and 1.3 Mev.

MDDC - 1191 Drawing No. 2W1693C: "Z" Regulator, Main Power Amplifier, Schematic, Radiation Laboratory, 1 p., August 30, 1944.

A schematic drawing of a "Z" regulator, main power amplifier is presented. A tube and parts list is included.

MDDC - 1192 Drawing No. 2W1893B: "Z" Regulator, Control and Preamplifier, Schematic, Radiation Laboratory, 1 p., August 30, 1944, decl. 6/3/47.

The preamplifier shown is used in connection with current regulation. The diagram also gives the circuit values and manufacturer's parts list by number.

MDDC - 1193 Calibration of a Ra + Be Neutron Source by the B(n,α)Li Reaction, by F. G. P. Seidl and S. P. Harris, 7 p., June 23, 1947. (See also Review of Scientific Instruments, Vol. 18 p. 897-899, December 1947).

The characteristics of the Ra + Be source which were studied are listed below. This source was manufactured according to a procedure described by Anderson and Feld. (Rev. Sci. Inst., Vol. 18, p. 186, 331, 1947.) These results are classified as "preliminary" because each of the three completed runs contains an inaccuracy that cannot be attributed intrinsically to the method.

Calculations of the number Q of neutrons emitted per second from a Ra + Be source were made according to the equation:

$$Q = V_{He} \frac{N_A}{ft} \frac{m}{M} \frac{I_s}{I_p} \frac{\Sigma t}{\Sigma_B}$$

where V_{He} represents the volume of helium in cubic centimeters at STP produced by the pile irradiation, N_A is a constant depending upon units, f is the fraction of source neutrons absorbed in the solution, t the length of time of irradiation both by the source and in the pile, m/M is the fraction by weight of the pile-irradiated solution that when thoroughly mixed with similar inactive solution yielded a measured γ-activity proportional to I_p, I_s is proportional to the γ-activity of the source-irradiated

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solution and Σ_t/Σ_B denotes the ratio of total neutron capture to capture by boron.

The principal errors in these three runs were as follows: a helium leak occurred through the heated portions of a glass palladium furnace used during run 1; a complete recovery of the helium in run 2 was impossible because of an accidental breakage; there was a leak from the outer atmosphere during run 3. Corrections could be made in runs 1 and 3 for the principal errors whereupon Q = 5.54 x 10^6 neutrons per sec, and Q = 5.48 x 10^6 neutrons per sec, respectively, from runs 1 and 3.

The following characteristics for the Ra + Be source were as follows:

Mass of radium ($RaBr_2$)	504 mg;
Mass of beryllium	3,000 mg;
Number of neutrons emitted per second, Q = $(5.5 \pm 0.4) \times 10^6$ sec^{-1}.	

MDDC - 1194 The Rate of Decay of Fission Products, by K. Way and E. P. Wigner, 30 p., May 19, 1947. (MonP-303).

By considering the fission products as a sort of statistical assembly, calculations have been made of the number of β-disintegrations per second and of the total energy emitted per second at any time after fission has taken place. The results are in good agreement with experiment. The theoretical work is based on the assumption that the mass of a nucleus of mass number A and charge Z is given by $a(Z_0(A)-Z)^2+b$. Empirical values for a and b are used. Use is also made of an approximate empirical relationship between half-life and disintegration energy. A further basic hypothesis which is important for the results at very short times after fission has taken place is that, in the most probable way of splitting, the chain lengths of the light and heavy fragments are equal and that there is not much deviation from this most probable mode of fission. The average number of β-disintegrations per fission is found to be 6.3.

MDDC - 1195 The Natural Abundance of Isotopes of Stable Elements, by J. R. White and A. E. Cameron, 18 p., n.d., decl. 8/8/47.

The natural abundances of the following elements have been determined by mass spectrometric techniques (two 60° mass spectrometers were used): lithium, magnesium, silicon, potassium, calcium, chromium, iron, nickel, copper, selenium, bromine, strontium, silver, cadmium, indium, tin, antimony, tellurium, tantalum, tungsten, rhenium, thallium, and lead. Individual procedures are discussed.

The determinations were made in connection with the program of separation of these isotopes in the electromagnetic process pilot plant. In some cases these are repetitions of previous determinations, but were usually made by somewhat different techniques. In several cases the only previous data were those obtained by mass spectrographic determinations involving photometry of a photographic plate.

A bibliography of 46 references is included.

MDDC - 1196 Equilibrium Pressures in the System Uranium-Uranium Bromide, by E. D. Eastman and A. E. Stickland, 6 p., n.d., decl. 7/31/47.

An experiment was performed to determine if the vapor pressure of UBr_3 was lowered due to the solubility of the metal by the dynamic or flow method.

The apparatus employed was the same in design as that used in measurements with lead chloride.

The vapor pressure of UBr_3 over a solution of U in molten UBr_3 was found to be close to the vapor pressure of pure UBr_3 which indicates a positive deviation from Raoult's law for UBr_3 in the U-UBr_3 solution.

MDDC - 1197 Effect of Total Body X-Ray on Weights of Organs in the Rat, by A. M. Brues, G. Sacher, and H. O. France, 11 p., June 1946. (CH-3835).

Weights and water content of organs were investigated in a group of growing male rats that had received 1498 r at 13.82 r/day average. The weights of the majority of the visceral organs were affected less than body weight as a whole; weights of muscle and femur were affected in the same ratio as body weight; and spleen, thymus, gonads, and gonadal fat were reduced out of proportion to body weight. Adrenal weights were normal. Water content per gram of tissue in muscle and bone of irradiated animals was 4.3 per cent greater than in the control animals. Thus the retardation in growth is similar to that seen in inanition except for the relatively greater effect on organs known to be radiosensitive.

Organ weights and total body weights of rats that had received single doses of X-ray up to 100 r several months previously, showed no deviations from the normal.

MDDC - 1198 The Status of Health and Protection at Hanford Engineer Works, by S. T. Cantril and H. M. Parker, 7 p., July 8, 1946. (CH-3570).

This document was written for and handed to the employees at Hanford Engineer works shortly after the dropping of the bombs on Japan.

The safety precautions taken are reviewed. The design of the plant incorporated every precautionary device or material necessary for safety. An intricate air conditioning system was installed, new instruments for detecting radiation and for handling the radioactive material were designed. Workers wore special badges with film which detected quantities of radiation. All instruments were continually checked and standardized. Special clothes were provided for the workers, and they received periodic physical examinations.

It is stated that, to date, no employee working in the H.E.W. has received an amount of radiation exposure which would be injurious.

MDDC - 1199 Uranium Poisoning - Review of Literature to 1942, by S. T. Cantril and J. J. Nickson, 6 p., December 15, 1942.

This review is divided into three headings: pathology, symptomology, and uranium poisoning in man.

On the whole, very little was found in the literature on uranium poisoning in man and even less dealing with chronic poisoning with which the authors are most concerned.

It is well established that the element is toxic, but the routes of absorption of uranium in various forms are not well established. It is known that the kidneys suffer damage when uranium is absorbed, and the signs of this toxicity can be seen in the urine. The central nervous system has also been seen to be damaged. It is likely that other organs also suffer but no definite information is available.

Experiments are underway to study chemical toxicity in the mouse, but no results are given in this report.

A bibliography is appended.

MDDC 1200 The Influence of Chronic Irradiation with Gamma-Rays at Low dosages on the Mutation Rate in Drosophila Melanogaster, by E. Caspari and C. Stern, 41 p., April 1947. (M-1966). (See Genetics, Vol. 33, p. 75-95, January 1948)

The experiments reported in this paper have been undertaken to study the question of whether or not the rule that the mutation rate is independent of the time of irradiation also holds for low dosages.

The rate of lethal sex-linked mutations in Drosophila exposed to gamma-rays of 2.5 r units per day through 21 days (total $52\frac{1}{2}$r) has been determined.

In a total of 108,215 chromosomes tested, no significant difference between experimentals and controls was found.

The difference between experimental and controls found in the present investigation is significantly ($P = 0.012$) different from that found by Spencer and Stern with the same dose of X-rays given at once.

By comparison of the present results with those obtained by Spencer and Stern and by Raychaudhuri it is concluded, that it is unlikely that the relative inactivity of the irradiation is due to wave length, temperature or glass container.

As possible causes for the inactivity of irradiation in the present experiment, different sensitivity of sperm at different stages of aging, and dependence of induced mutation rate on a time factor at low dosages are being considered.

The latter explanation could form the basis of a tolerance dose for mutations. It cannot be accepted, however, unless the other possibilities of explanation are definitely excluded.

A bibliography of 30 references is appended.

MDDC - 1201 The Emf of Cells with Uranium: Uranium Halide Couples in Fused Salt Electrolytes, by D. D. Cubicciotti and M. J. Sienko, 10 p., n.d., decl. 7/31/47.

The emf of galvanic cells at high temperatures was measured using uranium metal in equilibrium with its chloride as one half of the cell, the other half of the cell being some reference electrode such as silver - silver chloride. Several designs of cells tried are described. A value of 2.83 volts/eq at 1170°K and also at 990°K is considered as the most probable value for the potential of the uranium halide couple.

MDDC - 1202 Apparent Specific Activity of Uranium in a 2 π Geometry Chamber, by B. B. Cunningham, A. Ghiorso, and A. H. Jaffey, 10 p., n.d., decl. 7/31/47. (ANL-JJK-14B-25).

Using material from three different sources, values were consistently obtained for the specific activity of uranium which are 2-3% higher than the value reported by Kovarik and Adams. In calculating specific activity values the counter geometry was assumed to be 50%. Calculation of the absorption error, and a consideration of counter characteristics would indicate, however, that none of the values obtained should be lower than the true value by more than about one per cent.

Excellent agreement ($\pm 0.1\%$) was obtained in the case of uranyl nitrate from two different sources. Uranium from uranium metal gave a somewhat (1%) lower value at 30% greater sample thickness. When the thickness of sample from this source was reduced by 1/2, a good agreement ($\pm 0.2\%$) was obtained for all sources.

The average value for all sources and all samples counted was found to be 1548 $\pm$12 alpha-particles /min/mg ($U_I + U_{II} + U^{235}$). This figure is to be compared with that of 1501 found by Kovarik and Adams, and that of 1517 found by R. Schiedt.

Three explanations of the discrepancy between these values and those of Kovarik and Adams, suggest themselves.

1) The values found by Kovarik and Adams are in error.
2) The authors' sources were uniformly contaminated with an alpha emitter of high specific activity.
3) Greater than 50% of the uranium alpha particles emitted by these samples were counted in the apparatus used here.

Further work will be required to determine which, if any, of these explanations is correct.

MDDC - 1203 The First Isolation of a Synthetic Element: $_{94}Pu^{239}$, by B. B. Cunningham and L. B. Werner, 53 p., n.d., decl. 8/13/47.

The first isolation and weighing experiments as well as several later experiments of a similar nature are described, all of which led to rather closely concordant values for the specific activity and half-life of $_{94}Pu^{239}$.

The experiments described include the isolation of approximately one microgram of $_{94}Pu^{239}$ as the fluoride; the preparation of about twenty micrograms of plutonium^{239} as a solution of pure plutonium nitrate in nitric acid; measurements of the specific alpha activity of pure plutonium oxide; proof of the oxidation number of plutonium in plutonium(IV) iodates; early microgram scale observations of the chemical properties of plutonium compounds. The half-life of $_{94}Pu^{239}$ is given as $(2.43 \pm 0.12) \times 10^4$.

MDDC - 1204 **Personnel Monitoring at Clinton Laboratories, by L. J. Deal and K. Z. Morgan, 23 p., March 24, 1947.**

Discussions under the following headings are assembled: the operational procedures of the Health Physics Department; pocket meters: description and function, performance, maintenance, and testing; film meters: description, film packet, processing, calibration and exposure determination; general personnel monitoring results: rough treatment test on pocket meters, pocket meter background, comparison of pocket meter and film meter readings, determination of average total body exposure from meter readings, radiation exposures recorded.

MDDC - 1205 **Preparation and Composition of Plutonium (IV) Acetylacetonate, by J. S. Dixon and C. Smith, 8 p., n.d., decl. 8/4/47. (ANL-JJK-14B-30).**

Plutonium (IV) acetylacetonate has been successfully prepared on a one-milligram scale by the addition of a sodium hydroxide solution of acetylacetone to a solution of Pu (IV) sulfate. The reddish-brown crystalline acetylacetonate melts at 170-173°C and is soluble in chloroform and benzene. Assays for plutonium content indicate the formula $Pu(C_5H_7O_2)_4$. The vapor pressure of the compound has been measured as $4 \pm 1 \times 10^{-4}$ mm Hg at 140°C.

A diagram of an apparatus for the sublimation of plutonium (IV) acetylacetonate is included.

MDDC - 1206 **The Heats and Entropies of Pu(III), Pu(IV) and Pu(VI) in 0.5 M Perchloric Acid at 25°C, by M. W. Evans, 17 p., n.d., decl. 8/27/47. (ANL-JJK-14B-19).**

The heats of the reactions of hydrogen peroxide with ceric ion and of ferrous with ceric and with dichromate ions have been measured. The heats of oxidation of Pu(III) to Pu(VI) by ceric ion and of Pu(III) to Pu(IV) by dichromate ion have been measured. All measurements were made in 0.5 M perchloric acid. The differences in entropy of the +3 and +6 ions and of the +3 and +4 ions have been calculated, and an estimate of the entropy of each ion has been made. The entropies are compared with those determined by Kasha and Sheline and the agreement is good.

The experiments were carried out at 298.1°K but the reference values are for 291°K and so the heats determined correspond exactly to neither temperature. The values which may be used at either temperature without serious error are as follows:

$$\Delta H_{(form)}Ce^{+4} = -134.2$$

$$\Delta H_{(form)}Cr^{+3} = -55.5$$

$$Fe^{++} + H^{+} = Fe^{+++} + 1/2H_2 \quad \Delta H = +9.9$$

$$Pu^{+3} + H^{+} = Pu^{++} + 1/2H_2 \quad \Delta H = +12.15$$

MDDC - 1207 Acute Radiotoxicity of $(Ba\text{-}La)^{140}$ in Rats and Mice. Part IV. Lethal Action and Clinical Symptoms, by R. D. Finkle, R. H. Snyder, and W. E. Kisieleski, 5 p., June 1947. (CH-3825).

In the $(Ba\text{-}La)^{140}$ experiments, rats and mice were injected intraperitoneally with toxic doses of radiobarium. The dose of $(Ba\text{-}La)^{140}$ necessary to kill 50 per cent of the injected mice in one month was about 3 to 5 $\mu c/g$. The dose required to kill half of the injected rats in 90 days was about 4 $\mu c/g$.

The mice that died and some of those that recovered showed outward symptoms of injury. They were lethargic, and there was usually some loss of hair. Before death, the eyes became watery and the lids encrusted, and finally, the eyes were sunken and nearly closed. The eye symptoms and lethargy noticed in the mice were also apparent in the rats. The animals were usually nervous and irritable when disturbed.

Large quantities of inert barium chloride were injected subcutaneously into mice. A similar experiment with inert lanthanum was performed. The experiment designed to test chemical toxicity of barium and to test another route of administration was unsatisfactory.

MDDC - 1208 Determination of Deuterium in Water - A Mass Spectrometric Method, by R. Fischer, R. Potter, and R. Voskuyl, 7 p., n.d., decl. 8/29/47.

In mass spectrographic analyses for deuterium in water, the water cannot be used directly because of the ready adsorption of water molecules on the walls of the vacuum apparatus. It is necessary, instead, to use for the analysis hydrogen which is in isotopic equilibrium with the water to be analyzed. Equilibria conditions are derived which are directly correlated to isotopic concentrations determined by mass spectrographic analysis. Standard water samples have been prepared and the calculated concentrations have been compared with the known values. The observed inaccuracy of the method is of the order of one per cent.

A bibliography of 12 references is appended.

MDDC - 1209 On the Association of Certain Hematomas with Myelencephalic Blebs in the Mouse, by A. B. Grobman, 5 p., August 16, 1946. (II-188-7080).

Certain liver and testis hematomas and a case of situs inversus viscerum have been described by Bagg, in a series of papers, along with the kidney, eye, and foot abnormalities which are generally considered to be the expression of the gene for myelencephalic blebs. Apparently Bagg believed the liver and testis hematomas to be associated with the gene my.

Grüneberg discounts the association of situs inversus viscerum with the other anomalies but accepts Bagg's allocation of the hematomas. In the present note this latter allocation is questioned.

The mice with which Bagg worked were all descended from a single stock which had been exposed to X-radiation. Grüneberg is of the opinion that the original stock was already heterallelic for my. After the anomalies appeared the mice were selectively inbred for the defects and undoubtedly they were made homozygous for my.

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Grobman's material is thought to be free of my. The mice are unrelated to Bagg's my/my mice; they originated from well known stocks in which my has never been reported; and they have practically none of the kidney and eye defects associated with the gene.

Comparison of the frequencies of testis hematomas gives a chi-square of 1.10 with one degree of freedom and suggests a low occurrence of testis hematomas in mice regardless of the presence of the gene for myelencephalic blebs.

However, the comparable values for the liver hematomas do not support a similar conclusion. Here the chi-square value of 9.09 with one degree of freedom ($P < .01$) is consistent with an association of these hematomas with my.

Since Grobman's + my mice exhibit frequencies of the testis hematomas similar to those of Bagg's my/my mice, it appears likely that testis hematomas (and probably pancreas hematomas and situs inversus viscerum) are not always to be attributed (either directly or indirectly) to the gene my. The data do not support such a conclusion regarding liver hematomas although it is not unlikely that strain differences, independent of my, may be chiefly involved.

MDDC - 1210 Effects of Total Body X-Irradiation on Rats. Part I. Lethal Action of Single, Paired, and Periodic Doses, by C. W. Hagen, Jr. and E. L. Simmons, 47 p., May 1947. (CH-3815).

Exposures of Sprague-Dawley white rats to single doses of 200 kvp X-radiation demonstrated a median lethal dose of 600 r which was not markedly dependent upon sex, weight, or, in the case of females, stage of the estrous cycle at the time of irradiation. Deaths within 30 days were most frequent between the fourth and eighth, and between the tenth and fifteenth post-irradiation days, indicating the existence of at least two processes leading to death in the "acute" period.

Male rats exposed to 300 r were less resistant to X-rays than unexposed animals for at least 6 weeks. During the first 3 weeks after the initial exposure, recovery was exponential at a rate of 8.2 per cent per day. Beyond 3 weeks, the rate of recovery apparently decreased.

Deaths that occurred after daily exposure to doses greater than 50 r per day occurred in less than 30 days; whereas with lower daily doses, the period of survival was greatly extended. These results are compatible with the recovery rate of 8.2 per cent per day determined by paired-dose studies and indicate that after high daily doses, the lethal mechanisms are the same as those after single doses. With low daily doses, other mechanisms may operate.

A bibliography of 19 references is appended.

MDDC - 1211 Note on the Composition of Uranium Peroxides, by J. W. Hamaker and C. W. Koch, 2 p., n.d., decl. 8/27/47.

The complete report is reproduced below.

Several samples of uranium peroxide were prepared and analyzed.

An excess of superoxol was added to 0.22 M uranyl nitrate solution and the mixture heated. The yellow powder, when filtered off, washed and air dried, gave the analysis shown in Table 1 (samples 1 and 2). The calculated formula of uranium peroxide agrees very closely with that reported before, i.e., $UO_4 \cdot 2H_2O$.

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Table 1. Analysis of Uranium Peroxides

Sample	Method of Washing	% U_3O_8	%H	%C	Kjeldahl %N	Ce^{+4} Titration % O peroxide	Formula Calculated
1	Water, alcohol ether	82.45	1.25	--	--	--	$UO_{3.98} \cdot 2.11\ H_2O$
2	Water	82.41	1.29	--	--	--	$UO_{3.96} \cdot 2.18\ H_2O$
3	Water, alcohol, ether	69.80	1.95	3.00	3.43	--	$U(O^- + O^=)_{4.17}(NH_4)_{0.99}$
4	Water	70.43	1.73	3.05	3.55	7.61	$U(O^-)_{1.94}(O^=)_{2.02}$ $(NH_4)_{1.01}(C_2O_4)_{0.51} \cdot 1.58\ H_2O$

At the same time an attempt was made to prepare the "crystalline" peroxide reported by A. Rosenheim and H. Daehr. Superoxol was added to a solution containing the calculated amounts of ammonium oxalate and uranyl nitrate to form uranyl ammonium oxalate and a minor fraction of the uranium was precipitated as a crystalline solid. These were the conditions reported by Rosenheim and Daehr, except that nitrate ions were present. As will be seen in Table 1 (samples 3 and 4), ammonium ion appears in the solid phase. The authors considered it very possible that the compound prepared by Rosenheim and Daehr also contained ammonium and oxalate ions. The solid was air dried before analysis. Its formula corresponds closely to $(NH_4)_2U_2O_8C_2O_4 \cdot (3\text{-}4)H_2O$.

MDDC - 1212 Oscilloscope Sweep Circuit and Delay Line for the Study of Transients, by W. A. Higinbotham, 11 p., June 26, 1944. (LADC - 223).

A description and operational instructions are given for a chassis (13" x 17" x 3" with 8-3/4" panel) which contains the following circuits: a trigger circuit giving repetition rates from 10 to 10,000 cycles; a triggered sweep with speeds from .5 microsec to .03 sec per inch, when used with a 5" cathode ray tube and accelerating voltage of about 1500 volts; a 1.2 microsec delay line with driving tube and one stage amplifier; power supply. The sweep speeds cover a wide range for general laboratory use. The sweep circuit is especially designed to give reliable operation on random pulsing.

Circuit diagrams are included.

MDDC - 1213 Complex Ions of Plutonium. I. Plutonium (III) in Solutions of Various Anions, by J. C. Hindman and D. P. Ames, 23 p., n.d., decl. 8/27/47. (ANL-WMM-158).

Absorption spectrum measurements have been made on plutonium(III) in perchloric, hydrochloric, nitric and sulfuric acids. The changes in the absorption spectrum were not marked, except in the very high anion concentrations. The anions in increasing order of this effectiveness in producing perturbations were perchlorate < chloride < nitrate < sulfate.

The small changes produced in the spectrum as the anion concentration varied suggested that either the complex forming tendency of this +3 ion is very low, or more probably, that the changes produced in the spectrum by complex formation are small. The latter hypothesis would be consistent with the supposition that the absorption bands are due to 5f electrons in plutonium(III). It is noted that the changes produced in the spectrum of Nd(III) and Pu(III) nitrate solutions with varying nitrate concentration are similar.

Seven figures are included.

MDDC - 1214 Ca^{45}: Production from Scandium in the Pile, Radiation Characteristics, and Preparation in Carrier-Free Form, by J. X. Khym, P. C. Tompkins, and W. E. Cohn, 14 p., n.d., decl. 8/12/47.

Carrier-free Ca^{45} has been prepared by bombarding Sc_2O_3 in the Clinton pile. The following reactions were found to occur.

$$_{21}Sc^{45} + {}_0n^1 \longrightarrow {}_{20}Ca^{45} + {}_1p^1$$

$$_{21}Sc^{45} + {}_0n^1 \longrightarrow {}_{21}Sc^{46} + \gamma$$

The preparation consisted of the following steps: (1) The exposure of high purity Sc_2O_3 to pile neutrons to produce Ca^{45}. (2) A semihot operation to separate the bulk of the Sc^{46} from Ca^{45}. (This eliminates the troublesome γ activity coming from the Sc^{46}. The activity remaining with the Ca^{45} fraction is fairly weak and may be handled in the laboratory without shielding). (3) The purification of Ca^{45} taking advantage of reactions which separate the remaining traces of Sc^{46} from Ca^{45} and which leave the Ca^{45} in a carrier-free and solid-free form. The radiations from Ca^{45} appear to be a single β with an energy of 0.3 Mev; Sc^{46} appears to have a 0.4 Mev β and a 1.4 Mev γ. These values do not agree with those in the literature.

MDDC - 1215 Complex Ions of Plutonium. XI. Transference Measurements, by C. K. McLane, J. S. Dixon, and J. C. Hindman, 21 p., n.d., decl. 8/18/47.

Electrical transference measurements were used to determine the sign of charge on the plutonium ion in various solutions.

The cells which were used in the experiments are illustrated.

The following generalizations were made as a result of this investigation:

(a) Pu(IV) and Pu(VI) form complex ions more readily than does Pu(III). The change from cationic to anionic behavior of Pu(IV) and of Pu(VI) occurs at about the same concentration range of nitric, hydrochloric and sulfuric acids. Neither Pu(IV) nor Pu(VI) forms a complex anion with perchlorate in 9-10 M $HClO_4$.

(b) The anions may be grouped according to their tendencies to form negatively charged plutonium complex ions as follows:

Strong:	sulfate, acetate, oxalate
Moderate:	nitrate, chloride
Weak or zero:	perchlorate

This grouping is based largely on Pu(IV) behavior. Pu(III) and Pu(VI), where investigated, lead to similar grouping of anions.

In addition evidence was obtained for a positively charged phosphate complex and for a stable positively charged fluoride complex.

(c) It was also found that oxidized neptunium [i.e., Np(VI)] behaves similarly to Pu(VI) in solutions of various anions.

MDDC - 1216 The Chemical Identification of Radioisotopes of Neodymium and Element 61, by J. A. Marinsky and L. E. Glendenin, 16 p., July 1947. (See also Journal of the American Chemical Society, Vol. 69 p. 2781-2785, November 1947).

Studies of the elution characteristics of rare earth ions from Amberlite IR-1 absorption columns, using buffered citrate solutions, have shown that the order of elution is the reverse of atomic number, with yttrium falling near gadolinium. The position in the elution sequence can be used to identify individual rare earth elements, and useful separations can be achieved.

Column separations on fission product mixtures containing activities of praseodymium, neodymium, and element 61 have led to the first positive chemical identification of isotopes of element 61 of 47h and 3.7y half-life.

Radiochemical studies and fractionations have established the decay characteristics, genetic relation, and mass assignments of 11d Nd^{147}, 3.7y 61^{147}, 1.7h $Nd^{(149)}$, and 47h 61^{149}.

Radiochemical work on neodymium and element 61 is reviewed.

MDDC - 1217 Second Report of Handy Study Program, by M. Nickson and L. Warner, 21 p., January 1, 1947. (CH-3753).

Methods to determine early radiation damage or damage which has occurred without the individual's being conscious of any change fall into two catagories, macroscopic and microscopic.

Two methods were used in the laboratory for determining macroscopic changes: (1) direct inspection of the hands. (2) The hands were photographed, the photographs enlarged and the enlarged photographs were studied.

There are two macroscopic changes in the skin after acute and chronic radiation, namely erythema following acute radiation, and atrophy after chronic radiation. Unfortunately, both radiation erythema and/or atrophy will also result from stimulation other than radiation. Microscopic examinations of the vessels at the base of the nail were made.

Of the 593 individuals studied for radiation damage to finger ridges, 18% had some abnormality. All of these abnormalities were minimal. Reversible changes due to mechanical flattening of the ridges were found among machinists, carpenters, and others doing manual labor. Such findings which may be confusing after a single examination can be excluded by repeated studies after time intervals to allow for regeneration.

Capillary counts were found to range between 18 and 22 in over half of the individuals studied and between 18 and 27 in 80%. Persons with dark skin pigment had slightly lower counts whereas persons over 50 years of age had counts in the high portion of the average range. Sex had no effect on the count. Radiation exposure at levels received in the laboratory had no effect on the count during the period of time covered by this study.

This report is a continuation of studies described in MDDC - 1270.

MDDC - 1218 Identification of Pu(IV) Oxalate Complexes in Oxalic Acid Solutions, by W. H. Reas, 14 p., n.d., decl. 8/13/47.

The formulas of plutonium(IV) ions in oxalic acid solutions have been determined by measuring the equilibrium solubility of $Pu(C_2O_4)_2.6H_2O$ in 0.75 M HNO_3 at various oxalic acid concentrations. It was found that the data obtained in this manner could be interpreted by assuming the complexes in solution were $Pu(C_2O_4)^{++}$, $Pu(C_2O_4)_2$, and $Pu(C_2O_4)_3^{=}$. The values of the equilibrium constants for the formation of $Pu(C_2O_4)^{++}$, $Pu(C_2O_4)_2$, and $Pu(C_2O_4)_3^{=}$ from $Pu(C_2O_4)_2.6H_2O$ are given. These complexes have been correlated with their characteristic absorption bands in the visible spectrum, and the positions of these bands are given. Spectroscopic evidence is cited for the existence of the complex $Pu(C_2O_4)_4^{-4}$ in ammonium oxalate solutions.

MDDC - 1219 Control of Hemorrhagic Syndrome and Reduction in X-Irradiation Mortality with a Flavonone, 6 p., June 26, 1947. (II-188-7176).

Single dose total body X-irradiation to dogs produces a conspicuous depression of all peripheral blood elements with a resultant or associated hemorrhagic diathesis. This hemorrhagic manifestation is probably the predominant cause of death in these radiated animals although the anemia, thrombocytopenia, lymphopenia, neutropenia and associated sepsis may play a correspondingly important role. Although such bleeding tendencies may be ascribed to the thrombocytopenia or heparinemia the factor of decreased capillary permeability must be considered. The administration

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of a flavonol glycoside, rutin, a substance reported to have the property to reduce the capillary fragility to normal, reduces the mortality of radiated dogs from 67% to 13% without significant alteration of the depressed thrombocytes or white blood cell levels

MDDC - 1220 Thorium Standard Samples, by C. J. Rodden, 47 p., June 1947. (A-2945).

In connection with the work on the determination of thorium in ores and minerals, a sample of monazite sand was obtained from the Lindsay Light and Chemical Company which was ground to pass 100 mesh. This sample was then analyzed by cooperating analysts. In addition to being used on a standard monazite sand with known thorium and uranium content, this sample was mixed with dunite which had been ground to pass 100 mesh in order to have a series of samples containing 0.001; 0.01; 0.02; 0.05; 0.1; and 1% thorium, respectively. In this connection, it was desirable to obtain a reliable value on the thorium and uranium content of the original sample of monazite. Through the cooperation of Michael Fleisher of the U. S. Geological Survey, Howard Kremers of the Lindsay Light and Chemical, and the United Kingdom Laboratories, the results given were obtained.

The value 9.65% ThO_2 which was obtained on the standard monazite sand was used in the preparation of the low grade thorium mixtures.

MDDC - 1221 Studies of Porphyrin Metabolism. IV. The Effect of Irradiation on Coproporphyrin Excretion, by S. Schwartz, et al., 38 p., November 25, 1946. (CH-3719).

The effect of irradiation exposure on coproporphyrin excretion has been studied in 38 dogs. A diminished excretion of this porphyrin in urine and feces was found to follow the administration of lethal or nearly lethal doses of total body X-ray, strontium^{89}, and plutonium. In most instances, a sharp increase in porphyrin excretion occurred during the terminal period.

Preliminary studies showed no significant change in the ratio of the two coproporphyrin isomers (I and III) following irradiation.

A bibliography of 16 references is appended.

MDDC - 1222 The Chemical Properties of Uranium Hydride, by F. H. Spedding, et al., 32 p., n.d., decl. 7/24/47.

Uranium hydride is a pyrophoric powder in many of its reactions, it acts as a powerful reducing agent. It dissolves readily in oxidizing acids but very slowly, if at all, in non-oxidizing acids. It is converted to the uranyl salt by treatment with strong oxidizing agents and also by several weak oxidizing agents. The latter include silver salts, mercuric salts, and antimony salts in hydrochloric acid solution. The reaction between uranium hydride and halogen or hydrogen halide gases at about 250°C offers a convenient method of preparing anhydrous uranium halides from uranium metal. There is also a smooth reaction of uranium hydride with hydrogen sulfide, steam, carbon dioxide, phosphine, ethylene, methane, and phosgene to form binary compounds of uranium.

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There is no reaction at room temperature with organic liquids other than chlorinated solvents.

Uranium hydride is completely wetted by mercury, but the process is reversed when the "amalgam" is brought in contact with air, water, or hydrogen sulfide at room temperature.

A bibliography of 55 references is appended.

MDDC - 1223 Plutonium Project Recond, Volume IX-B, Chapter 8, edited by N. Sugarman, Argonne National Laboratory, 131 p., n.d., decl. 8/18/47.

This report is made up of a series of papers, numbered MDDC - 1223 - A through MDDC - 1223 - CC respectively. These papers are individually abstracted below:

MDDC - 1223 - A Procedure for the Isolation of Zn Fission Activity, by J. M. Siegel and L. E. Glendenin, 6 p., n.d., decl. 8/18/47.

A procedure for the isolation of Zn from fission material, which is based on the precipitation of $ZnHg(SCN)_4$ with $HgCl_2$-KSCN reagent and further purification by Bi_2S_3 and combined $Fe(OH)_3$-$BaCO_3$ scavengings and by evaporations with HBr, is presented. A decontamination factor of $\sim 10^9$ is obtained to provide high radioactive purity.

MDDC - 1223 - B Procedure for the Isolation of Ga Fission Activity, by J. M. Siegel and L. E. Glendenin., 6 p., n.d., decl. 8/18/47.

A procedure is given for the separation of Ga from fission material, making use of extraction of Ga from 6 M HCl with ether, scavenging with Bi_2S_3 and $Fe(OH)_3$, evaporation with concentrated HBr and precipitation of $Ga_4[Fe(CN)_6]_3$ with $K_4Fe(CN)_6$. A decontamination factor greater than 10^9 is obtained to provide high radioactive purity.

MDDC - 1223 - C Procedure for the Isolation of Ge and As Fission Activities, by L. Winsberg, 4 p., n.d., decl. 8/18/47.

A procedure based on the distillation of $GeCl_4$ and $AsCl_3$ with HCl is given for the isolation of Ge and As fission activities. Effective decontamination to produce high radioactive purity is obtained.

MDDC - 1223 - D Determination of Se Activity in Fission, by L. Winsberg and L. E. Glendenin, 5 p., n.d., decl. 8/18/47.

An improved procedure is given for the separation of Se from fission material, making use of distillation with HBr and separation of elementary Se with SO_2 in concentrated HCl. Decontamination tests show that high radioactive purity is obtained, in particular with regard to Zr and Te.

MDDC - 1223 - E A Note on the Preparation of Carrier-Free Se Tracer Using a Szilard-Chalmers Reaction, by H. Gest and R. R. Edwards, 2 p., n.d., decl. 8/18/47.

Two methods of separating elementary Se from pile-irradiated ammonium selenite are given.

The ammonium selenite was irradiated in the Clinton pile producing Se^{83}, Se^{81*}, Se^{81}, and Se^{75}. On dissolving in HCl and extracting with CS_2, 20 per cent of the Se activity was found in the Se fraction which was evaporated and the Se taken up in concentrated HNO_3.

A somewhat larger yield of Se activity was obtained by an adsorption separation.

The HCl solution of the irradiated selenite was filtered through a fine sintered glass filter and washed with water. 28 per cent of the original Se activity was removed by boiling concentrated HNO_3.

Preparations made by both of these methods are low in inactive Se.

MDDC - 1223 - F The Determination of Br Activity in Fission, by E. L. Brady and G. W. Campbell, 2 p., n.d., decl. 8/18/47.

A procedure to separate Br activity from the fission products is given. This method makes use of oxidation of Br with MnO_4^- and extraction of the Br_2 formed with CCl_4.

The method yields 90 per cent of the carrier Br^- free of radiochemical contamination. Data are not available to show the completeness of interchange of Br carrier with radioactive Br.

MDDC - 1223 - G Improved Determination of Bromine Activity in Fission, by L. E. Glendenin, R. R. Edwards, and H. Gest, 4p., n.d., decl. 8/18/47.

An improved procedure is given for the separation of Br from fission material. Addition of an H_2S reduction step assures the interchange of radiobromine with carrier, while the use of $NH_2OH.HCl$ to reduce Br_2 to Br^- without reducing I_2 to I^- has eliminated the necessity of specific I removal.

Contamination by other fission activities is negligible. The chemical yield is 50 per cent or greater.

MDDC - 1223 - H A Note on the Preparation of Carrier-Free Br Trancer from Deuteron-Bombarded Se, by R. Overstreet and L. Jacobson, 1 p., n.d., decl. 8/18/47.

Selenium metal is fused on a copper target and bombarded with deuterons in a bell jar. The Se is distilled with 6N HNO_3. The distillate, containing the Br^{82}, is collected in CCl_4 which is then washed three times with distilled water. Sufficient Cl_2 gas is added to the CCl_4 to produce a definite yellow color, and the mixture is placed in direct sunlight for at least one hour. At the end of this period, the CCl_4 mixture is extracted with an excess of either Na_2SO_3 or $Na_2S_2O_3$ to give a solution of tracer Br free of significant amounts of inactive Cl carrier.

Above note is reprinted in full.

MDDC - 1223 - I A Note on the Reactions of Tracer Bromine, Exchange with Silver Bromide and Lack of Exchange with Bromate Ion, by R. R. Edwards and H. Gest, 3 p., n.d., decl. 8/18/47.

Carbon tetrachloride extracts of tracer Br free of carrier can be made by $KMnO_4$ oxidation of Br^-. Part of the tracer is re-extractable by water; some of the remainder has special reactivity towards CH_3CHBr_2 or $NaHSO_3$.

Tracer Br exchanges rapidly with freshly formed AgBr and fails to exchange in 100 minutes at room temperature with neutral BrO_3^- solutions.

MDDC - 1223 - J Determination of Sr and Ba Activities in Fission, by L. E. Glendenin, 8 p., n.d., decl. 8/18/47.

A procedure for the radiochemical determination of Sr and Ba, based on the precipitation of $Sr(NO_3)_2$ and $Ba(NO_3)_2$ by fuming HNO_3 and $Fe(OH)_3$ scavenging for additional purification, is given. The method is simple and has been thoroughly tested for effectiveness of separation from other fission activities. Strontium carrier standardization is effected by neutralization of oxalic acid solution with NH_4OH to prevent contamination of $Sr_2C_2O_4.H_2O$ with $SrCO_3$.

MDDC - 1223 - K Preparation of Carrier-Free Sr Tracer from Deuteron-Bombarded Rb, by R. Overstreet, L. Jacobson, K. Scott, and J. E. Hamilton, 2 p., n.d., decl. 8/18/47.

A procedure to prepare carrier-free Sr activity produced from a (d, 2n) reaction on Rb is described. The Sr is carried by $Fe(OH)_3$, and the Fe is removed by ether extraction from HCl solution.

MDDC - 1223 - L Phosphate Method for the Determination of Zr and Cb Activities in Fission, by E. L. Brady and D. W. Engelkemeier, 6 p., n.d., decl. 8/17/47.

A procedure is presented for the tandem isolation of Zr and Cb from fission material. The method makes use of the precipitation of Zr and Cb in a 0.5M H_3PO_4 solution to separate these elements from other fission activities. The separations of Cb and Zr from each other are based on the formation of a soluble complex oxide of Cb when a precipitate of ZrO_2 and Cb_2O_5 is fused with K_2CO_3.

MDDC - 1223 - M Oxalate Method for the Determination of Zr and Cb Activities in Fission, by E. P. Steinberg, 5 p., n.d., decl. 8/18/47.

A rapid and accurate method for the separation of Zr and Cb from fission product mixtures is presented. Satisfactory decontamination from other fission elements is indicated.

The method is based on the formation of soluble complexes of both elements with oxalic acid; the insolubility of $Th(C_2O_4)_2$, which is used as a scavenger, in acid solution; the specific precipitation of

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Cb as oxide on destruction of the oxalate complex with chloric acid; and the separation of Zr from the acid solution as phenylarsonate. The Cb_2O_5 and zirconium phenylarsonate are both soluble in oxalic acid and can be dissolved and recycled to insure a high degree of radioactive purity.

MDDC - 1223 - N A Note on the Comparison of the Phosphate and Oxalate Methods for the Determination of Zr Activity in Fission, by E. L. Brady, 1 p., n.d., decl. 8/18/47.

The complete text of the note is reproduced below.

A comparison has been made of the phosphate and oxalate methods for determining Zr activity on fission. Steinberg found that the radioactive yield of Zr^{95} as determined by the phosphate method is lower than the fission yield obtained by the oxalate method. A careful redetermination of the fission yield of 65d Zr^{95} was made, using the phosphate method on samples of the same material used by Steinberg. The fission yield values were 2.0, 3.2, 4.2, and 3.8 per cent, and Steinberg's values were 4.4, 4.7, 4.7, 4.6, 4.3, and 4.2 per cent. The oxalate method gives much more reproducible results and a better radiochemical yield; the purity appears to be equally good, and the time required is much less. For these reasons the oxalate method is to be preferred.

MDDC - 1223 - O Determination of Zr Activity in Fission by the Barium Fluozirconate Method, by D. N. Hume, 7p., n.d., decl. 8/18/47.

A rapid and direct method has been developed for the determination of Zr activity in fission mixtures. Radioactive interchange has been shown to be complete. Decontamination from other activities is satisfactory.

The original solution, with added Zr carrier, is treated with HF forming soluble complexes of Zr and Sb. The addition of La ions removes rare earth and alkaline earth activities on LaF_3.

Two precipitations give essentially complete removal. Zirconium is then separated from other fission activities by addition of Ba ion to precipitate insoluble $BaZrF_6$. The corresponding Cb compound is quite soluble and the separation satisfactory. Further purification is achieved by dissolving the precipitate twice in boric and nitric acids and reprecipitating it with excess HF and Ba ion. Barium is removed, and Zr 's prepared for weighing by precipitation with cupferron or phenylarsonic acid and ignition to the oxide.

MDDC - 1223 - P Determination of Zr Activity in Solutions Containing Much La, by D. N. Hume, M. Humphrey, and C. I. McCabe, 4 p., n.d., decl. 8/18/47.

A procedure for the determination of Zr activity in concentrated La solutions is presented. The method is a modification of the fluozirconate procedure; it makes use of a preliminary $ZrPO_4$ precipitation to prevent loss of Zr carrier by coprecipitation on LaF_3.

The chemical yield is 50-60 per cent.

It is recommended that this procedure be used if 50 mg or more La is suspected to be present in the sample taken for analysis.

MDDC - 1223 - Q A Comparison of the Oxalate and Fluoride Methods for the Determination of Zr Activity in Fission, by D. E. Waters and D. N. Hume, 4 p., n.d., decl. 8/18/47.

A comparison is made of the radiochemical yield obtained by the oxalate and fluoride methods for the determination of Zr activity in fission. The oxalate method is shown to give much lower yields than the fluoride method, which is quantitative.

MDDC - 1223 - R A Note on Analytical Methods for Short-Lived Zr and Cb Activities in Fission, by S. Katcoff, B. Finkle, and E. Hoagland, 2 p., n.d., decl. 8/18/47.

The radiochemical methods of analysis for Zr and Cb proved to be inadequate for shorter-lived activities because of contamination.

Iodine and molybdenum analyses revealed the presence of the 2.4h I daughter of 77h Te and the 67h Mo, thus identifying the contaminants. A procedure involving two Cb_2O_5 precipitations, addition of Te^{+6} carrier, reduction to Te^{+4} with HCl, precipitation of Te with SO_2, and a Bi_2S_3 scavenging precipitation from oxalic acid solution gave excellent results. By this procedure decay curves of 75m Cb showing practically no contamination were obtained.

Attempts to remove the activity which invariably interferes with the analysis of bombarded UNH for short-lived Zr by the $BaZrF_6$ method were unsuccessful.

MDDC - 1223 - S Preparation of Carrier-Free Zr Tracer, by N. E. Ballou, 3 p., n.d., decl. 8/18/47.

A procedure is presented for the preparation of carrier-free Zr tracer, making use of the co-separation of Zr activity from fission material on thorium iodate. The method is rapid, and the radiochemical yield is ~ 60 per cent. The purity of the final product is satisfactory.

MDDC - 1223 - T Preparation of Carrier-Free Zr and Cb Tracer, by J. A. Marinsky and D. N. Hume, 4 p., n.d., decl. 8/18/47.

A rapid procedure for the preparation of very pure carrier-free Zr and Cb tracer involves the chloroform extraction of the cupferrides of Zr and Cb activities from irradiated UNH solution. Zirconium and columbium form very stable chloroform-soluble cupferrides in acid solutions and are separated from other fission elements almost quantatively to yield a mixture of pure Zr and Cb activities. A minimum of operations is required, and the method is easily adaptable to remote control.

MDDC - 1223 - U The Preparation of Carrier-Free Zr and Cb Activities, by R. Overstreet and L. Jacobson, 5 p., n.d., decl. 8/18/47.

A procedure is presented for the tandem preparation of carrier-free Zr and Cb activities from irradiated UNH, making use of the carrying of Zr and Cb on thorium iodate to isolate these elements from most of the other fission products. The separation of Cb and Zr from each other is based on the formation of a soluble complex oxide of Cb by K_2CO_3 fusion.

MDDC - 1223 - V A Note on the Removal of Zr and Cb from Amberlite Resin Absorbent, by D. N. Hume, 2 p., n.d., decl. 8/18/47.

A preliminary investigation of samples of Amberlite IR-1 in adsorption column studies showed that HF removes most of adsorbed UX, Cb and Zr activity in one elution. After removal of UX by LaF_3 precipitations, MnO_2 was precipitated from a 10 M HNO_3 solution of the remaining activities and reprecipitated twice. Absorption curves indicated the activity carried on the MnO_2 to be Cb with small amounts of β contamination already shown by Glendenin and Gest to be Te. After solution of the MnO_2, a white residue remained, which was soluble in oxalic acid and insoluble in mineral acids and which carried all the activity. This carrier could not be separated and has not as yet been identified.

The filtrate from the MnO_2 precipitations to remove Cb from the HNO_3 and HF eluate of amberlite IR-1 resin was used as a source of Zr activity. Cerium carrier was added and oxidized to the quadrivalent state of $KClO_3$ in hot 10 M HNO_3. Addition of HIO_3 precipitated $Ce(IO_3)_4$, which carried Zr. After a reprecipitation, the ceric iodate was dissolved in HCl, and Ce^{IV} and IO_3^- were reduced with SO_2. The fact that precipitation of CeF_3 carried most of the activity shows that in the absence of hold-back carried Zr is markedly carried by rare-earth fluoride precipitates.

Ce and Zr were separated by fuming with $HClO_4$ to remove HF and treating with SO_2 and cerous oxalate.

MDDC - 1233 - W The Determination of Cb Activity in Fission, by L. E. Glendenin, 9 p., n.d., decl. 8/18/47.

The regular oxalate-chloric acid procedure for Cb does not separate Cb satisfactorily from Zr in phosphate solution, and a simple modification based upon the removal of Zr by the precipitation of $BaZrF_6$ has been devised. The separation of Cb from other fission activities including Zr is shown to be satisfactory by tracer tests. Tellurium is carried through the procedure to the extent of a few per cent but does not contribute significantly to γ counting.

MDDC - 1223 - X Preparation of Cb Tracer by Coseparation with MnO_2, by L. E. Glendenin and H. Gest, 4 p., n.d., decl. 8/18/47.

A procedure is presented for the preparation of carrier-free Cb tracer from fission material, making use of the carrying of Cb activity with MnO_2 precipitated by $KClO_3$ oxidation of Mn^{+2} in 10 M HNO_3. Yields of 40-85 per cent are obtained by this method. The final product contains a trace of Fe and a small amount of HCl. Absorption curves and chemical tests indicate a high degree of radioactive purity.

MDDC - 1223 - Y An Improved Preparation of Carrier-Free Cb Tracer with MnO_2, by J. M. Siegel, W. P. Bigler, and D. N. Hume, 5 p., n.d., decl. 8/18/47.

The MnO_2 procedure for the preparation of carrier-free Cb tracer from fission material has been modified to improve the yield of final product. The principal change is in the method of Te decontamination. The Te is removed by reduction of Te with SO_3 in 3 M HCl rather than by reduction of H_2TeO_4 with Zn since Zn^{++} interferes with the carrying of Cb and MnO_2.

MDDC - 1223 - Z Improved Determination of Ru Activity in Fission, by L. E. Glendenin, 13 p., n.d., decl. 8/18/47.

The distillation procedure for the radiochemical determination of Ru has been greatly improved by the development of a method for precipitating Ru metal in a reproducibly weighable form by reduction with Mg metal. Contamination by halogens has been eliminated by the addition of $NaBiO_3$ before distillation of Ru, to oxidize the halogens to their non-volatile oxyacids. The modified procedure is simple and rapid, and gives excellent decontamination from the other fission products.

MDDC - 1223 - AA Preparation of Carrier-Free Ru Tracer, by D. N. Hume, 6 p., n.d., decl. 8/18/47.

A simple procedure, adaptable to remote control, for isolation of carrier-free Ru activity from fission mixtures is described. Ruthenium is distilled as RuO_4 from a H_2SO_4 solution of $KMnO_4$.

The yield is high, element 43 does not distill, foreign ions do not contaminate the final product and the operations are safe.

MDDC - 1223 - BB Improved Determination of Ag Activity in Fission, by L. E. Glendenin, 5 p., n.d., decl. 8/18/47.

The procedure for the determination of Ag activity has been improved by the addition of $Fe(OH)_3$ scavenging steps. Tracer tests and separations of Ag from a fission product mixture indicate satisfactory decontamination from other fission activities including iodine.

The chemical yield is 75 per cent or better.

MDDC - 1223 - CC Determination of Sn Activity in Fission, by J. A. Seiler, 3 p., n.d., decl. 8/18/47.

A procedure to separate Sn activity from the other fission products is described. The method consists of precipitating SnS and then decontaminating by the precipitation of Sb_2S_3 from an oxalic acid solution. Zirconium and columbium hydroxide scavengings are performed next. Stannous sulfide is finally precipitated and converted to SnO_2 by concentrated HNO_3 for weighing and mounting.

MDDC - 1224 Inherited Situs Inversus Viscerum in Mice, by J. A. Tiben, D. R. Charles, and T. O. Sippel. 5 p., August 1946. (II-188-7079).

The authors believe that the Jackson Bagg line may have been the source of the situs inversus gene. A pedigree chart is presented.

Among the 227 offspring studied, situs inversus was detected in only 29. Causes of the deficiency have not yet been studied.

MDDC - 1225 Ion Exchange as a Separations Method. III. Equilibrium Studies of the Reactions of Rare Earth Complexes with Synthetic Ion Exchange Resins, by E. R. Tompkins and S. W. Mayer, 25 p., May 1947. (See Journal of the American Chemical Society, Vol. 69, p., 2859-2865, November 1947.)

Equilibrium studies of the distribution of rare earths between synthetic ion exchange resins and solutions of varying composition have been made. It was shown that for any given composition of solution the distribution coefficient of a rare earth between the two phases did not change as the ratio of the weight of Dowex 50 resin to the solution volume was varied. The exchange reaction between a rare earth ion and the ammonium resin compound was shown to follow the relationship predicted by the mass law. The exchange constants for several rare earths, equilibrated with the ammonium compound of Dowex 50 resin, vary. This shows that some separation of rare earths is possible without the use of complexing agents when this resin is employed. A study of the citrate complexes showed that the one in which three H_2Cit^- ions are combined with a rare earth ion is responsible for the relatively large separation factors between these elements. A preliminary, comparative study of the effectiveness of several exchangers and complexing agents was made.

Since the ammonium ion concentration, the total rare earth concentration, the citrate concentration and the pH are interdependent variables, it should be possible, from the results of these equilibrium studies, to choose a number of sets of "optimum conditions" for a column separation. When Dowex 50 is used in the column, the concentration of the rare earth ions in the solution may not exceed 3×10^{-4} M without adversely affecting the separation. With Amberlite IR-1, this concentration must be below 10^{-6} M. The pH of the citrate solution should not be greater than 3.2 since appreciable concentrations of the citrate ions $HCit^{-2}$ and Cit^{-3} interfere with the separation.

MDDC - 1226 The Physical Principles and Techniques of Autoradiographs, by G. A. Boyd, 17 p., July 1947. (II-188-7235).

The text of a talk presented before the Biological Photographic Association is covered.

The purpose of autoradiographic research is the location of a particular atom in a gross or histological section. Radioactivity as it pertains to this subject is reviewed with emphasis on alpha and beta rays.

Various techniques are presented and the advantages and disadvantages enumerated. As yet no quantitative method has been perfected which is sufficiently reliable to give a measure of the material present.

MDDC - 1227 A Phase-Shift-Analysis of the Scattering of Protons by Deuterons, by C. L. Critchfield, 24 p., n.d., decl. 9/10/47. (LADC-422). (See also Physical Review, Vol. 73 p. 1-6, Januray 1, 1948).

Numerical values for the S-wave and P-wave phase-shifts are deduced from the observed angular distribution of protons scattered by deuterons. The experimental results used are those obtained at Los Alamos in the energy range, 1.5 to 3.5 Mev. In reducing the results to phase-shifts the theoretical work on neutron-deuteron scattering, as presented by Buckingham and Massey, was used as a guide. It is found that the p-d phase-shifts are qualitatively similar to the calculated n-d phase-shifts, for the case of exchange forces between nucleons, except that the doublet P-wave is much more strongly refracted in the p-d results. The discrepancy may be evidence for a difference between the actual nuclear forces and the type of central, exchange forces assumed in the calculations. The results are definitely not similar to those for ordinary forces, however, and such forces would appear to be ruled out. Phase-shifts in S- and P-waves alone are not sufficient to represent the p-d results in the range of energies used, but it is necessary to include interference with D-waves.

MDDC - 1228 The Absorption and Fluorescence Spectra of Bivalent Europium Ion in Crystals, by S. Freed and S. Katcoff, 13 p., n.d., decl. 8/14/47.

Although bivalent europium ion (Eu^{++}) and trivalent gadolinium ion (Gd^{+++}) in crystals are isoelectronic, there is no resemblance in their spectra either as regards intensity or structure. Instead of the sharp spectrum of Gd^{+++} even at room temperature, the spectrum of Eu^{++} consists, both in absorption and in fluorescence, of broad bands which show signs of an underlying discreteness at liquid air temperatures and at the temperature of liquid hydrogen resolution of lines is achieved in some band regions.

The spectrum of Eu^{++} in crystals is perhaps one hundred to one thousand times as intense as the spectrum of the gadolinium ion. To obtain transmission, the bivalent salts were greatly diluted to form mixed crystals with the corresponding colorless strontium salt. In contrast with the spectrum of Gd^{+++}, the spectra of Eu^{++}, are rich in vibrational structure with an interval 215 cm^{-1} as especially prominent. The spectra of Eu^{++} are also exceptional in their strong dependence on the crystalline environment about the europium ions.

The character of the spectrum is ascribed principally to transitions between a sharp basic level $^8S_{7/2}$ with the seven "optical" electrons in the 4f shell and activated states having one of these electrons in a 5d, 6s, 6p, etc., or the lattice.

There are possibilities here that some of the sharp activated states which correspond to those in Gd^{+++} have nearly the same energy as those which have one electron in the outer shells of the ion or in the lattice and thus resonance arises between the "inner" and "outer" states. Some evidence is offered for such radiationless transitions and for transitions to the lattice.

MDDC - 1229 The Half-Life of Tritium, by M. Goldblatt, E. S. Robinson, and R. W. Spence, 1 p., n.d., decl. 8/26/47. (LADC-421). (See also Physical Review, Vol. 72, p. 973, November 15, 1947).

The half-life of tritium was measured by observing the decrease with time of the ion current from an ion chamber containing a mixture of hydrogen and tritium. The preliminary value of the half-life obtained is 10.7 ± 1.0 years. The previously reported value was 31 years (1940).

MDDC - 1230 High Vacuum Valve and Seal, by L. D. P. King, 5 p., n.d., decl. 9/10/47. (LADC-427). (See also Review of Scientific Instruments, Vol 19, p. 83-84 February 1948).

A simple two-way valve and a method of making a seal are described, both well adapted to large or small port openings in high vacuum work. The valve gate consists of two rigid flat surfaces on which the gaskets are mounted. The plates are normally drawn together but can be pushed in front of the ports and forced apart by the action of a cam fixed to rod. A round rubber gasket held in a special groove of one surface pushed against another flat surface produces an excellent vacuum seal. The metal to metal seat prevents injury to the rubber from excessive pressure or the exposure of the rubber to the vacuum system.

Drawings are included.

MDDC - 1231 A Determination of the $S^{32}(n,p)P^{32}$ Cross Section for Neutrons of Energy 1.6 to 5.8 Mev, by E. D. Klema and A. O. Hanson, 18 p., n.d., decl. 9/10/47. (LADC-418). (See also Physical Review, Vol 73, p. 106-110 January 15, 1948).

Sulfur was irradiated with known fluxes of monoenergetic neutrons having energies of 1.6 to 5.8 Mev. The formation of P^{32} by the $S^{32}(n,p)P^{32}$ reaction was detected by means of the P^{32} beta activity. The cross section for the reaction at the lower neutron energies has the same form as the penetrability of the protons from the reaction through the Coulomb barrier. At the higher energies the cross section for the reaction reaches an approximately constant value of 0.3×10^{-24} cm^2.

MDDC - 1232 Preliminary Studies in the Toxicity of Beryllium - The Effect of Intratracheal Injection of Beryllium in Experimental Animals, by C. W. LaBelle and M. R. Cucci, 19 p., July 1947. (II-186-7257).

Beryllium and certain of its industrially important compounds have been administered to rats by the intratracheal route as an experimental introduction to the field of inhalation toxicity of beryllium dusts. The tracheal route permits known amounts of toxic materials to be introduced directly into the lungs of animals and allows a more rapid appraisal of pulmonary toxicity than is possible by the more cumbersome inhalation studies.

In the absence of information on the nature of beryllium poisoning in animals via the lung, the tracheal studies were designed to supply information on: 1) the relative toxicities (MLD) of insoluble beryllium dusts suspensions and certain soluble beryllium compounds, 2) the type of

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physiological response, whether acute or chronic, 3) the variables which might offer a means of appraising beryllium toxicity.

The 48-hour MLD for beryllium metal dust and the insoluble beryllium compounds, the oxide, the carbonate, and the carbide, were all greater than 100 mg of material per kg of body weight of rat; that of the soluble compounds, beryllium fluoride, sulfate, and oxyfluoride, was 15, 10, and 2 mg of salt per kg of body weight, respectively. These values were comparable to the MLD via the tracheal route of such acidic salts of heavy metals as copper and zinc sulfate, and mercuric chloride. It was concluded, because of the similarity in response, that the deaths from soluble compounds were caused by direct mechanical interference with normal lung function rather than by any specific toxic effect of beryllium per se.

The type of response was distinct for the soluble and insoluble beryllium materials. The soluble beryllium compounds produced acute toxic death. The insoluble beryllium materials produced effects of a chronic nature. Deaths from the latter group of materials did not occur before the 100th day following exposure and became most prominent between this period and the 300th day.

In addition to decreased growth response, hematologic changes gave greatest promise of the indicating current injury from beryllium. Changes in the blood picture were confined chiefly to increases in the polymorphonuclear leukocytes. These findings were not uniform as was characteristic of beryllium poisoning in general in animals. At death pathological changes in the lungs of rats given beryllium metal dust consisted of an inflammatory reaction and in some instances necrosis.

At present, no animal host has been found nor method of producing the pulmonary type of injury in animals identical with that of men, despite the fact that several animal species have been investigated and numerous methods of modifying the pulmonary exposure have been tried.

MDDC - 1233 Certain Aspects of the Acute Toxicity of Beryllium Following Intraperitoneal Injection, by E. A. Maynard, W. L. Downs, and H. C. Hodge, 3 p., July 1947. (II-188-7259).

Following intraperitoneal injection in rats and mice, the LD_{50} dose based on 24-hour mortalities was determined for various Be compounds. A few rabbits and guinea pigs were also injected. The soluble Be salts gave indication of toxicity of varying degree; the insoluble salts were practically non-toxic. Saline solutions were less toxic than aqueous solutions. Young (weanling) rats and mice were more resistant to Be toxicity than were older animals.

MDDC - 1234 Preliminary Data on Rat Feeding with Beryllium, by E. A. Maynard, W. L. Downs, and H. C. Hodge, 16 p., July 1947. (II-188-7258).

At a dietary level of 5%, Be sulfate and Be carbonate completely inhibited growth of rats and caused some mortality. A rickets-like condition occurred in these rats. Food intake was reduced by about 50% but this did not account for all growth inhibition as shown by a paired feeding experiment. Return to stock diet after a prolonged period of ingestion of Be salt allowed rapid but not complete growth recovery. Be sulfate was more toxic to old rats than to weanlings, but with Be carbonate mature rats seemed to be more resistant than weanlings. Be carbonate at a level of 2.3% of the diet caused some weight depression in rats. Be metal at a 10% dietary level, and Be oxide at a 5% dietary level did not affect the growth of rats.

MDDC - 1235 A Review of Analytical Methods for Beryllium, by W. F. Neuman, 7 p., 1947.

Procedures for the analysis of biological specimens for content of beryllium are discussed. Two colorimetric, one fluorescent, and the spectrographic methods are presented, together with data on the accuracy, sensitivity, and specificity of each.

The advantages of and experimental procedures for the use of beryllium isotopes are also reviewed.

MDDC - 1236 Half-Life of Tritium by Arron Novick, 2 p. (See also Physical Review Vol. 72 p. 972, November 15, 1947).

By collecting and measuring the He^3 produced by beta decay of tritium, a value of 12.1 $\pm$ 0.5 years has been obtained for the half-life of tritium. This value is based on results on two samples and is markedly different from the accepted value of 31 $\pm$ 8 years obtained by counting "radio-scale" quantities.

MDDC - 1237 The Pathological Anatomy of Acute Experimental Beryllium Poisoning and Peripheral Blood Changes Resulting from Intravenous Administration of Beryllium Sulphate, by J. K. Scott, 15 p., July 1947. (II-188-7234).

The lesions produced in the organs following a single intravenous administration of hydrated beryllium sulphate are described. The lesions of the lungs and eyes of animals exposed to the above compound are reviewed. When the beryllium sulphate is given intravenously, midzonal focal necrosis of the liver cells, necrosis of cells of the distal one-third of the proximal convoluted tubules of the kidney and degenerative changes in the cells of the hemopoietic system are produced. Following exposure of animals to beryllium sulphate dust (100 mg/m^3, 8 hours daily for eleven days), inflammatory pulmonary lesions are produced, which vary in intensity with different species. Pulmonary edema, terminal bronchitis, and focal atelectasis are the most commonly observed lesions. The eyes of some species exposed to this dust develop conjunctivitis, keratitis, and corneal ulcers.

Following a single intravenous administration of beryllium sulphate, rather sharp changes occur in the elements of the peripheral blood. These consist of a secondary anemia (probably resulting from intravascular lysis of red cells), a leukocytosis, and an increase in the number of circulating platelets.

MDDC - 1238 The Production of High Energy Neutrons by Stripping, by R. Serber, 24 p., July 21, 1947. (BP-101). (See also Physical Review Vol. 72 p. 1008-1016 December 1, 1947).

When a target is bombarded with high energy deuterons, a narrow beam of high energy neutrons is produced by a process in which the proton in the deuteron strikes the edge of the nucleus and is stripped off, while the neutron misses and continues on its way. The cross section for this stripping process is $\sigma = 1/2\ \pi RR_d$, where R is the nuclear radius and R_d is the deuteron radius, or $\sigma = 5A^{1/3} \times 10^{-26}\ cm^2$. The yield of neutrons from a 1/2" Be target, (in which energy loss for 190 Mev deuterons

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is 15 Mev) is nearly 2%. The neutrons come out with an energy spread around $1/2E_d$ having a half-width $\Delta E1/2 = 1.5(E_d \epsilon_d)^{1/2}$. Here E_d is the kinetic energy of the deuteron, ϵ_d its binding energy. For light nuclei the half width of the neuteron angular distribution is $\Delta 0\ 1/2 = 1.6(\epsilon_d/E_d)^{1/2}$. The half width increases linearly with atomic number, primarily because of the deflection of the deuteron by the coulomb field as it approaches the nucleus, and, to a lesser extent, because of multiple scattering in the target. The increase in half width from Be to U is about 25%. The calculated half widths and angular distributions agree well with the measurements of Helmholz, McMillan, and Sewell.

An equal number of high energy protons are produced by stripping processes in which it is the neutron that hits the nucleus.

MDDC - 1239 Some Biological Effects Due to Nuclear Fission, by C. A. Tobias, P.P. Weymouth, L. R. Wasserman, and G. E. Stapleton, 12 p., n.d., decl. 9/5/47. (BP-84). (See also Science, Vol. 107, p. 115-118, January 30, 1948.)

Conditions for producing biological effects with slow neutron induced disintegrations of Li, B or fissionable materials are discussed. An experiment is described where colloidal UO_2 containing enriched uranium was injected into mice. When exposed to slow neutrons all these mice died, presumably due to the effect of fission recoils. Control mice, that received colloidal uranium, but no neutron radiation, or neutron radiation but no colloid, or the combination of uranium and X-rays did not die. The lethal effect of fission recoils is greater than that of a physically equivalent dose of phosphorus beta rays.

MDDC - 1240 Acute Radiotoxicity of Injected Yttrium^{91}, by D. S. Anthony, 14 p., June 1946. (CH-3838).

Male rats in groups consisting of five animals each were given intracardial injections of Y^{91} at dose levels of 1, 3, 5, 7 and 10 μc/g of body weight. A control group of five animals was given isotonic saline. The excretion, retention, and distribution of the yttrium was measured, and its effect on survival and growth was observed.

The average total excretion of Y^{91} to the time of death (from 76 hours to 24 days) was a little less than 30 per cent of the injected dose. About 25 per cent was excreted in the first four days. During the first four days, nearly 75 per cent of the excretion was via the urine; while between the fourth and the ninth days, nearly 90 per cent of the excretion was via the feces.

The average total retention at death (average time, 8.5 days) in 15 rats was 68 per cent of the injected dose. This retention was distributed grossly as follows: about 55 per cent in the carcass, 11 per cent in the entire viscera, and 2.5 per cent in the femur. The highest total retention in the viscera was found in the liver (6 per cent) while the highest retention/gram of soft tissue was found in the kidney (1.7 per cent). The concentration in the femur was three times higher than the highest concentration in the soft tissues.

The 30 day LD_{50} was between 1 and 3 μc/g, indicating a toxicity nearly twice as great as that observed with other fission products. The explanation of the high toxicity of Y^{91} is not apparent from the data in this experiment. Although there were no deaths in the period between 4 weeks and 6 months, all 4 of the remaining rats that had been given 1 μc/g died between 6 and 8 months. Three of these deaths were due to tumors.

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The growth rate, as measured by increase in body weight, was depressed approximately 10 per cent even by the lowest (1 μc/g) dose of Y^{91}.

MDDC - 1241 The Effect of X-Rays on the Metabolism of Small Intestine and Its Permeability to Glucose, by E. S. G. Barron, W. Wolkowitz, and J. A. Muntz, 14 p., February 3, 1947. (CH-3725).

The experiments presented in this paper demonstrate that X-rays produce immediate metabolic disturbances in the small intestine. All the experiments were made on rats which received total body irradiation. Four hours after irradiation, there was an abrupt drop of respiration in the small intestine, a diminished absorption of glucose, and a diminished phosphorylation of fructose. When rats were sacrificed 24 hours after irradiation, the respiration was within normal limits, although there was still inhibition of phosphorylation. Forty-eight hours after treatment, there was inhibition of respiration in some segments of the small intestine. The inhibition increased 72 hours after treatment; the rate of phosphorylation of fructose was unimpaired. There was some inhibition of respiration 96 hours after treatment. Anaerobic glycolysis was generally normal. There was a linear relationship between the inhibition of glucose absorption and the amount of irradiation.

A bibliography of 9 references is appended.

MDDC - 1242 The Thermodynamic Properties and Equilibria at High Temperatures of Uranium Halides, Oxides, Nitrides and Carbides, by L. Brewer, L. A. Bromley, P. W. Gilles, and N. L. Lofgren, 68 p., n.d., decl. 7/31/47.

This document has been revised and new data on the heats of formation of aqueous ions has been added. The revised document is identified as MDDC - 1543.

MDDC - 1243 The Maintenance of Animals Containing Radioactive Materials, by P. Britton, P. Lear, C. L. Prosser, and E. Tyree, 49 p., December 16, 1946. (CH-3742).

Species housed in the animal farm which consists of twenty rooms are pigeons, mice, rats, rabbits, guinea pigs, dogs, goats, and chickens. Various species are housed in the same room as infrequently as possible. The diets of the animals are given. They consist primarily of standard national brands and various supplements.

Cage cleaning consists of scrubbing the parts of each cage with a stiff wire brush, washing them with hot water under pressure, and sterilizing. A discussion of the general maintenance procedure for the various types of cages is included.

All animal rooms are air-conditioned and in the "hot rooms" the air is changed about every 15 minutes.

Farm workers wear masks, rubber gloves, and laboratory clothes.

A new, more efficient type of cage was designed. The most important feature of the new cage is that the support for the screen floor was outside the confines of the cage. Stainless steel is the preferred metal for cage construction. Photographs and working drawings of cages for mice, rats, guinea pigs, rabbits, and goats, and several types of metabolism cages are included in this paper. Cage decontamination is accomplished with the aid of complexing agents such as citric acid or sodium tartrate. Under certain conditions, nitric acid is used.

MDDC - 1244 Preparation of Fission Products for Use in the Experimental Biology Section, by A. Broido, 7 p., November 1946. (CH-3709).

This report describes the methods used in the preparation of fission products in amounts of 50-1000 mc. Two methods of separation, precipitation and adsorption, were used. The co-precipitation of small concentrations of one element on a precipitate of some other "carrier" element was adopted for early separation work, but the only co-precipitation method extensively used for fission products was the lead sulfate precipitation for Ba^{140} and Sr^{89}. When techniques of adsorption of fission products on IR-1 Amberlite resin columns were developed, this method of separation largely replaced that of co-precipitation. The absorption method was used to prepare Sr^{89}, Ba^{140}-La^{140}, Zr^{95}-Cb^{95}, Ce^{144}-Pr^{144}, and Y^{91} with a specific activity of the order of 100 mc per mg of solid.

MDDC - 1245 Note on the Determination of Nitric Acid in Uranyl Nitrate Solutions, by R. E. Connick, 3 p., September 8, 1945.

A rapid method is described based on the precipitation of uranium peroxide by excess hydrogen peroxide, according to the reaction:

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$$UO_2^{++} + H_2O_2 + XH_2O = UO_4 \cdot XH_2O + 2H^+$$

The solution is then titrated with standard base without removing the precipitate, the H^+ formed by the uranium peroxide reaction being titrated along with any free action in the solution. It is necessary to know the uranium concentration in order to calculate the concentration of free acid.

The method has not been tested thoroughly but present data indicate it is satisfactory under the conditions tried.

MDDC - 1246 The Solubility of Uranous Oxalate, by G. D. Dorough, 11 p., n.d., decl. 7/8/47.

Methods based on alpha activity measurements have been developed for the determination of small amounts of uranium in solution, and these methods have been applied to the determination of the solubility of uranous oxalate under a variety of conditions.

The two methods employed for the preparation of samples were the electrolytic plating method which is accurate and applicable to very low concentrations of uranium and the filter paper method which is slightly less sensitive and less accurate but considerably more rapid and convenient. Complete procedures are presented.

The experimental values for the solubility of uranous oxalate in HCl solutions do not fit any simple solubility product, due to hydrolysis of the uranous ion, and perhaps complexing of the uranous ion with chloride.

The solubility of uranous oxalate in H_2SO_4 acid is considerably greater presumably due to complexing of the uranous ion by sulfate ion.

Solubility product calculations indicate the hydrolysis of uranous ion to $U(OH)^{+++}$ is nearly complete.

MDDC - 1247 Biologic Effects of Long-Continued Whole Body Irradiation with Gamma Rays on Mice, Guinea Pigs, and Rabbits. IV. Biologic Action of Gamma Radiation on the Breeding Behavior of Mice, by M. K. Deringer, W. B. Heston, and E. Lorenz, 29 p., October 25. 1946, decl. 8/4/47. (CH-3729).

These experiments were designed to study the effects of continuous exposure to gamma radiation of low intensity on LAF_1 hybrid mice with respect to: (1) sterility; (2) dominant mutations, particularly dominant lethals as evidenced by reduced size of the litters of irradiated mice; and (3) genetic changes (translocations) in the progeny of the irradiated mice. Female mice exposed to total doses of 770 r and 880 r on the 8.8 r and on the 4.4 r per 24 hours per day, and on the 8.8 r per 8 hours per day levels showed sterility effects, some producing litters of reduced size and others being sterile. Females exposed to a total dose of 550 r on the 4.4 r per 8 hours per day level bred but with reduced litter size. Male mice receiving a total dose of 1,760 r at the rate of 8.8 r per 8 hours per day were sterile on removal from the field but regained fertility in two months. Males receiving total dose of 880 r and 1,100 r on the 8.8 r per 8 hours per day level bred normal size. Males receiving total doses up to 1,100 r on the 4.4 r per 8 hours per day and on the 4.4 r per 24 hours per day levels bred comparably to the controls. Breeding results obtained for female mice on 1 hour, 8 hour, and 24 hour exposures do not differ significantly and failed to demonstrate any effect of the rate of administration of the dose. Female mice exposed to a single dose of 300 r whole body X radiation at the rate of 41 r per minute

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produced one litter of reduced size and were sterile thereafter. The sterilized females did not recover their fertility but the males did. Breeding results for female mice exposed to a total dose of 440 r at the rate of 4.4 r per 24 hours per day entering the field at three, four, and five months of age failed to show any age effects. No evidence for the production of genetic changes was obtained in mice receiving chronic exposures, or for the production of translocations in the offspring of male mice receiving a total dose of 1,100 r at the rate of 8.8 r per 8 hours per day or of female mice reeeiving a total dose of 770 r at the rate of 8.8 r per 24 hours per day.

MDDC - 1248 Acute Radiotoxicity of $(Ba\text{-}La)^{140}$ in Rats and Mice. Part I. Preparation and Administration of the Emitters, by R. Finkle, R. Snyder, and P. Tompkins, 11 p., August 1946. (CH-3828).

Barium^{140} and its daughter, lanthanum^{140}, were obtained from uranium fission. The radiochemical composition of the different samples, as measured under absorption equivalent to 8 mg/cm^2 Al, fell within the following ranges: Ba^{140} - 43 to 49%, La^{140} - 44 to 50%, $Sr^{(89\text{-}90)}$ - 2 to 8%, all others 1% or less.

The radioactive solutions were administered by intraperitoneal injection. The bottles were mounted behind lead shields and the personnel was rotated to reduce each individual's exposure to gamma rays.

Three series of experiments were made using mice, and two series, using rats. One ml was the largest volume injected into a mouse, and six ml or less were injected into the rats.

At intervals after the experiment was begun, samples of excreta were collected. Urine and feces were collected together from each group of mice, while the rats were kept in individual cages over funnels with glass bulb-type separators so that separate analyses of urine and feces were possible. An mg of inactive barium and lanthanum each was added to the collection containers to reduce loss by adsorption on the glass walls. Urine was diluted to a known volume and the radioactivity measured. This was untreated except for the addition of formalin as a preservative. Feces were digested with HNO_3 to dryness and then ashed. The ash was dissolved in dilute HCl and diluted to a known volume for measurement of radioactivity. After digestion and ashing, fairly large amounts of the fecal ash were insoluble in HCl. About half of the radioactivity was carried on this insoluble matter. For analyses, this material was suspended and the activity of an aliquot of the suspension was measured. Tissues were dried and ashed at 700°, and the ash was dissolved in dilute acid.

As a check on the accuracy of the analytical procedure, the total excreta and carcasses of several groups of mice and rats were measured. When results were corrected for decay from the time of injection, the over-all recovery in mice was found to be between 80 and 120 per cent with an average of 101 per cent. In the rats the average total recovery was 96 per cent.

MDDC - 1249 Attempts to Reduce Uranium from Bromide Solutions in Ethyl Bromide and Related Solvents, by B. J. Fontana, 5 p., n.d., decl. 9/8/47.

Attempts have been made to reduce both UBr_4 and UBr_3 from ethylbromide-benzene solutions, ethyl bromide-hexaethyl benzene solutions, ethyl bromide solutions and n-propyl bromide solutions. In most cases the solubilities were too low to give a sufficiently conducting solution, even with the addition of other salts to the bath. In ethyl bromide both electrolytic and chemical reactions were observed but they never led to the reduction of any measurable amount of the bromide to uranium metal.

MDDC - 1250 Studies in the Dry Chemistry of Plutonium Fluorides, by S. Fried and N. R. Davidson, 11 p., n.d., decl. 9/8/47. (ANL-JJK-14B-18).

Plutonium tetrafluoride does not react with dry oxygen at temperatures up to 600°C while PuF_3 apparently undergoes the reaction.

$$4\ PuF_3 + O_2 \underset{\text{vacuum}}{\overset{600°C}{\rightleftharpoons}} 3\ PuF_4 + PuO_2$$

Plutonium tetrafluoride decomposes to PuF_3 and fluorine (presumably) at temperatures of about 900°C in vacuum. This decomposition has been observed to take place in vessels made of platinum, BeO, and CaF_2 so that it is difficult to envisage this reaction as one with the material of the containers. Plutonium tetrafluoride does not decompose to PuF_3 in vacuum in contact with platinum at 600°C.

It has been suggested that the apparent decomposition of PuF_4 to PuF_3 at high temperatures is really a disproportionation of the type

$$2\ PuF_4 \longrightarrow PuF_3 + PuF_5$$

with the PuF_5 then decomposing on the glass collecting surface according to the equation

$$PuF_5 \longrightarrow PuF_3 + F_2$$

MDDC - 1251 Chemistry of Plutonium(V) Stability, Spectrophotometry, 34 p., n.d., decl. 7/8/47. (ANL-JJK-14B-31).

The absorption spectrum of plutonium(V) near pH 3.5 was found to be practically identical with one previously published for an 0.5 M HCl solution. This spectrum does not change apparently up to pH 9. No evidence for $PuO_2(OH)$ at pH 9 was found.

The absorption spectra of plutonium(V) solutions in the presence of perchlorate, nitrate, or chloride ions were found to be practically identical even in 10 M nitrate and 8 M chloride solutions. This makes it doubtful that appreciable complexing of plutonium(V) occurs by nitrate or chloride ions, even at these high concentrations of salt. Plutonium(V) is reasonably stable between pH 2 and pH 5 at a concentration of ca 1.8 g Pu/l, in 0.05 M perchlorate solution at room temperature. Rapid disproportionation occurs below pH 1.5 and above pH 7.

Plutonium(V) in solution of nitrate and chloride ions (up to 10 M nitrate and 8 M chloride) is quite stable at room temperature at a concentration of 0.1 g Pu/l at pH 3.5, showing practically no disproportionation in 6 days.

The stability of plutonium(V) at pH 3.5 room temperature decreases considerably with increasing concentration. For example, a solution at a concentration of 0.5 g Pu/l showed practically no disproportionation (or reduction) after ten days, whereas a solution of 5 g Pu/l showed 10% disproportionation (and reduction) in the same time interval. A similar concentration dependence appears at high pH; with decreasing concentration a higher pH can be obtained without rapid disproportionation.

The stability of plutonium(V) solutions at pH 3.5 decreases considerably with increasing temperature. The more concentrated solutions appear to be expecially sensitive towards increase in temperature.

A bibliography of 24 references is appended.

MDDC - 1252 Effects of X-Rays on Rabbits. Part I. Mortality after Single and Paired Doses, by C. Hagen and G. Sacher, 35, p., December 9, 1946. (CH-3754).

Mortality statistics were collected on 227 young adult rabbits treated with single doses of X-rays. The distributions of times of death for males and females show that there are three distinct modal times of death in the first days after exposure. The first peak of deaths occurred in the first day after treatment, and males were more sensitive than females at this time. The second peak appeared between the fourth and eighth days, and was shown only in the females. The main peak of mortality occurred at ten days and showed little difference between the sexes.

The LD_{50} for the entire population, based upon all deaths in the first 20 days, was 800 r. When animals which died during the first three days were excluded from the population, the LD_{50} for the remaining group was 810 r, and the standard deviation of the survival curve was 140 r. The LD_{50} for killing in the 4-20 day period was 850 r for males and 790 r for females. One-day killing showed little dependence on dose.

Animals of either sex weighing more than 2 kg were found to be less sensitive than animals weighing less than 2 kg. It is not known whether this is a constitutional factor or an age factor.

Mean survival time of the decedents at each dose level was found to decrease as dose level increased. Males survived longer than females and heavy animals longer than light animals in a given dose group.

Deaths continued to occur in the 800 r and 900 r survivors during the second and third months after treatment. The rate of mortality was higher in the 900 r group.

Forty-eight animals, which survived for 100 days after initial doses of 500 r to 900 r, were given second doses of 800 r. Time distribution of deaths showed the same characteristics as the distribution of deaths after single doses, but with quantitative changes. Relative sensitivities of the two sexes were preserved in the one-day mortality but were reversed in the 4-20 day mortality. Sensitivity of the total population after second doses was comparable to the sensitivity of the heavy group after single doses. This lack of change of sensitivity after second doses was interpreted tentatively as arising from an overall balance between resident injury, which would lead to an increase in sensitivity, and selection, which would tend to decrease sensitivity of the survivors of the initial dose. Some evidence was observed of the dependence of survival after second dose on size of first dose, which tended to support the hypothesis that selection is operative.

MDDC - 1253 Comparative Late Effects of Periodic Doses of Fission Neutrons and of Gamma Rays, by P. S. Henshaw, et al., 84 p., June 1946 (MonH-115).

This study was undertaken to obtain information on occupational hazards associated with fast neutrons and gamma rays. Four strains of mice, picked for special characteristics, were used as test material. The all-purpose albino strain CF-1 was used for the large scale tests because of its sturdiness and availability. Colored ABC animals were used to check the CF-1, C58, and A-Strain mice were employed, respectively, because they normally show a high spontaneous incidence of leukemia and pulmonary tumors. Regarding the latter it was presumed that such animals would furnish the most fertile soil for blood and lung neoplasias and accordingly would provide the most sensitive test material for such effects.

Small daily doses of fast neutrons (.115 to 13.0 n) and gamma rays (1 to 17.2 r) were administered 6 times weekly to the whole bodies of treated animals. As a rule, each experimental group consisted of approximately 100 animals. Both general and specific control groups were maintained in equally large numbers.

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All animals were weighed and examined periodically. Records were kept of the time of death and regular sacrifices were made and tissues saved for histological examination. Autopsies were performed on all moribund or dead animals and the cause of death determined when possible.

Most of the animals died either in a state of atrophy or with leukemia (mediastinal lymphomatosis). The time of death after treatment began, followed a regular pattern and furnished a means of quantitatively comparing the effectiveness of the different treatments and methods of exposure. The fast neutron doses measured in "n" were found to be from 8 to 35 times more effective than gamma rays measured in "r". The threshold value for this radiation was found to be below 0.115 n of fast neutrons per day and about 1 r of gamma rays. In CF-1 mice about 10 times as much radiation per day was required to produce a threshold change as was required to shorten the life span detectably.

Some differences were noted in the responses of different strains of animals to radiation but these were more a matter of degree than of type; no fundamental differences were seen in the different sexes.

The quantitative results based on survival time indicate that the degree of biologic effect varies not only with dose, but also the density of ionisation produced.

Although the incidence of leukemia was significantly increased in CF-1 animals, the occurrence of lung tumors was only slightly, if any, modified by the treatments given. Only questionable evidence of increased lung tumor incidence was observed in animals which normally show a high spontaneous lung tumor incidence.

MDDC - 1254 Comparative Late Effects of Single Doses of Fission Neutrons and of Gamma Rays, by P. S. Henshaw, et al., 48 p., June 1946. (MonH-116).

Having obtained information about the late effects of small daily doses of fast neutrons and gamma rays (MDDC - 1253), the authors now present the results of a study of the late effects caused by the same radiations when single large doses are administered.

Experiments were carried out using CF-1 and ABC mice. As a rule more than 100 mice were used for each experimental sample. Single neutron doses of 26, 50, 78 and 90 n and single gamma ray doses of 500 and 700 r were given. Other special experiments to investigate the influence of dosage-rate and of massive doses were also carried out.

Acute illness consisting of emaciation and weight loss, lymphopenia and histologic damage to germinal tissues occurred at four days to two weeks. Recovery was rapid in the animals that survived and at three weeks it was difficult to distinguish the experimental from control animals. Such treated animals nevertheless died prematurely more or less in accord with the amount of radiation delivered. Evidence was obtained suggesting that the length of life varied exponentially with dose. It has been noted that 1 n is consistently more effective than 1 r in causing biological injury; the superiority of a fast neutron unit is greater when judged by late effects than when judged by acute lethal action. The incidence of leukemia (mediastinal lymphomatosis) was greatly increased - from 15 per cent in the controls to more than 60 per cent in the case of gamma rays (incomplete results).

The findings further substantiate the idea that the higher the concentration of ions the lower the dose of radiation required to produce a particular effect. Other evidence was obtained indicating that a single application of irradiation exposure is sufficient to induce malignant disease.

MDDC - 1255 Chemistry of Element 93. III. Absorption Spectrum Studies of Aqueous Ions of Neptunium, by J. C. Hindman, L. B. Magnusson, and T. J. LaChapelle, 24 p., n.d., decl. 9/10/47. (ANL-WMM-163).

The characteristics of the absorption spectra of the ions of neptunium of the +3, +4, +5, and +6 oxidation states in aqueous solution have been determined. Details of their spectra are given for solutions containing both complex forming and non-complex forming anions.

A number of graphs and tables accompany the report.

MDDC - 1256 Complex Ions of Plutonium. IV. The Nitrate Complex Ions of Plutonium(IV), by J. C. Hindman, 31 p., n.d., decl. 9/9/47. (ANL-WMM-181).

Analyses of spectral changes occurring in nitric acid and mixed nitric-perchloric acid solutions have showed that in nitric acid solutions below 4.6 molar, the principal complex ion present is the $PuNO_3^{+3}$ ion. In mixed perchloric acid-nitric acid solutions at 2.00 molar, total hydrogen ion concentration, the association constant, K_1, for the reaction:

$$Pu^{+4} + NO_3 \rightleftarrows PuNO_3^{+3}$$

has been found to be 2.9 ± 0.6. A study of mixed nitric acid-hydrochloric acid solutions at a constant 2.00 M hydrogen ion concentration has showed that the chloride complex of plutonium(IV) is much weaker than the nitrate complex.

Spectral evidence is presented for the formation of intermediate complexes between the $PuNO_3^{+3}$ ion and the $Pu(NO_3)_6^{=}$ ion. The latter ion has been characterized as the $Pu(NO_3)_6^{=}$ ion largely by transference measurements and isolation of the salt, $(NH_4)_2Pu(NO_3)_6$, isomorphous with $(NH_4)_2Ce(NO_3)_6$ and $(NH_4)_2Th(NO_3)_6$.

It is postulated that the similarity of the spectrum of the $Pu(NO_3)_6^{=}$ ion and that of Plutonium(IV) in methyl-isobutyl ketone is due to the fact that coordination of the oxygen atom of the methyl-isobutyl ketone to the metal of the neutral salt, $Pu(NO_3)_4$, produces the same effect on the field surrounding the plutonium(IV) ion as coordination to the oxygen of the nitrate ion.

A bibliography of 17 references is appended.

MDDC - 1257 Complex Ions of Plutonium. V. The Chloride Complex Ions of Plutonium(IV), by J. C. Hindman, 14 p., n.d., decl. 9/8/47. (ANL-WMM-140).

A summary of the available spectral data on plutonium(IV) chloride solutions is given. It is found that the formation of complexes containing several chloride ions for each plutonium(IV) ion is favored by a high ionic strength, a phenomenon observed earlier in the study of nitrate complex ions. Although the calculation of the formulae and association constants of the chloride complexes have not been found practicable with the data available, the evidence favors the conclusion that chloride ion has a weaker complex forming tendency than nitrate ion in low concentrations. It is pointed out that the spectral changes observed on formation of the chloride complexes differ from those found for other anions such as NO_3^-, $SO_4^=$, etc. The possibility of interpreting these spectral differences as due to differences in bond types is suggested.

MDDC - 1258 Absorption Spectra of Hydrochloric Acid Solutions of Plutonium Peroxide, by H. H. Hopkins, Jr., 2 p., January 1947. (CN-3689).

Preliminary observations have been made of the absorption spectra of plutonium peroxide dissolved in hydrochloric acid solutions. Plutonium peroxide precipitates were separated from 1 N hydrochloric acid and washed twice with 0.1 N hydrochloric acid. The precipitates were then dissolved in solutions of hydrochloric acid, a medium in which the several valence states of plutonium are relatively stable, and spectrophotometric observations carried out are described.

From the absorption spectrophotometric studies it was concluded that when plutonium peroxide dissolves in concentrated hydrochloric acid, a complex is formed. Heating disrupts the complex and the (IV) state appears. Peroxide reduces some plutonium to the (III) state, and prevents (VI) from forming. In dilute hydrochloric acid the reducing action is effective almost immediately and a small amount of the (III) state appears, although the (IV) state is most prominent.

MDDC - 1259 Absorption Spectra of Uranium(III) and Uranium(IV) in Molar Hydrocloric Acid, by J. J. Howland, Jr., 14 p., n.d., decl. 9/5/47.

The molar extinction coefficients for the absorption of U(IV) in 1 M HCl have been determined to ± 0.3 units (1% of the absolute value at the band maxima) over the range 4000-10,000 A from observations with a Beckman quartz spectrophotometer. The spectrum of U(III) in 1 M HCl has been observed with the same instrument, and the molar extinction coefficient evaluated with a relative accuracy of 2% and an absolute accuracy of 10% at the maxima, located at 4505, 5220, 5810, 6080, 6150, 7250, 9620, 8810, 9000 and 9710 Å. The intense sharp line of U(III) at 9000 Å can be interpreted as indicating that in the U^{+3}-ion, the electrons outside the radon configuration are all in 5f orbitals, even though this does not seem to be the case in the U^{+4}-ion. Chemical properties do not rule out the presence of three 5f electrons in uranium, making this element configurationally a member of an "actinide" series, even though actinium would be a poor prototype chemically. Optical analyses of U(III)-U(IV) mixtures give high apparent total uranium concentrations, possibly as a result of the formation of an unstable ionic species of U(IV) as U(III) is oxidized. The U(III) bands at 5220 and 7250 Å are useful for analytical purposes.

MDDC - 1260 Potential Measurements. The Pu(III)-Pu(IV) Couple, by J. J. Howland, Jr., J. C. Hindman, and K. A. Kraus, 14 p., n.d., decl. 9/9/47. (ANL-WMM-90).

From potential measurements at 25°C on the cell Hg; HgCl; saturated KCl || Pu(III), Pu(IV); Pt and on the cell Ag; AgCl; HCl || Pu(III), Pu(IV); Pt the formal potential of the Pu(III)-Pu(IV) couple was -0.966 ± 0.002 v in 1 M HCl, -0.953 ± 0.01 v in 1 M $HClO_4$, -0.92 ± 0.01 in 1 M HNO_3, -0.74 ± 0.02 v in 1 M H_2SO_4. Both potentiometric titrations and potential measurements on solutions of spectrophotometrically known Pu(III) and Pu(IV) concentration were employed. Crude experiments also indicate the approximate values -0.80 v in 1 M HCl -0.1 M H_3PO_4, -.059 v in 1 M HCl -0.6 M H_3PO_4, -0.60 v in 1 N H_2SO_4 -0.6 M H_3PO_4, -0.50 v in 1 M HF, -0.40 v in 1 M CH_3COOH-1 M CH_3COONa; all at 25°C.

A bibliography of 14 references is appended.

MDDC - 1261 Acute Radiotoxicity of $(Ba\text{-}La)^{140}$ in Rats and Mice. Part V. The Effect of $(Ba\text{-}La)^{140}$ on the Hematological Constituents of the Peripheral Blood of Rats and Mice, by L. O. Jacobson, 12 p., June 1946. (CH-3829).

In the $(Ba\text{-}La)^{140}$ experiments, mice and rats were injected intraperitoneally with toxic doses of radiobarium. Hematological data indicated that in mice the threshold for effects on hemoglobin and red blood cell count must be above 1.9 μc/g; that at 1.9 μc/g the heterophil and lymphocyte counts diminished, and that a dose of 0.2 μc/g appeared to be just below threshold. In rats, a dose of 0.5 μc/g decreased the white cell count by about 30 per cent 8 days after injection.

Histological results in mice are of two sorts: (1) damage to soft tissues, particularly the spleen, mesenteric lymph nodes, and lymphatic and epithelial tissues, of gastro-intestinal tract, which is probably due primarily to irradiation from lanthanum; and (2) damage to bone and bone marrow due to irradiation from deposited barium. Damage in soft tissues was seen 4 hours after injection, and damage in marrow was apparent at 17 hours. Much recovery in the soft tissues had occurred by 20 days.

The spleen took over much of the function of blood formation as the bone marrow was damaged. At 5 μc/g the red pulp became hyperactive with erythropoiesis and granulocytopoiesis; while at 1.5 μc/g the marrow was not so severely depleted and the red pulp showed no overactivity. The decrease in number of circulating heterophils and lymphocytes paralleled histological damage, although the decrease in lymphocytes at 1.5 μc/g was proportionately greater.

MDDC - 1262 Clinical Laboratory Examinations of Plutonium Project Personnel, by L. O. Jacobson, and E. K. Marks, 36 p., December 1946. (CH-3724).

The general inadequacy of the routine clinical laboratory examinations such as blood and urine studies in the detection of chronic radiation or uranium exposure in the tolerance range has become evident by experience on the plutonium project. Extensive hematological and urine studies at frequent intervals were conducted on project personnel (control and work hazard groups) for at least four purposes; (1) to provide a constant check for chance acute overexposure to these agents, (2) to discover any incipient damage to the hemopoietic system or urinary system from these agents, (3) to provide legal protection for the contractor and (4) to keep up morale of laboratory personnel. It was widely known to physicists and chemists that radiation and uranium were toxic to the hemopoietic system and urinary system respectively. The fact that frequent examinations of the blood and urine were being done gave the workers confidence that, in addition to the frequent physical monitoring of work areas and personnel for radiation hazards, the function of their "most sensitive" organ systems was being constantly scrutinized.

Only in relatively few instances did clinical laboratory evidence provide a clearcut indication that an acute or a chronic radiation exposure sustained by personnel had been excessive. The great individual variation in the steady state of the various hematological constituents of the peripheral blood and the multiplicity of factors which may adversely alter this steady state, temporarily or more chronically made interpretation of minor variations difficult and often impossible.

The need for more carefully controlled basic studies on the biological effect of physical and chemical agents such as radiation and uranium is stressed. Tests for incipient damage and the establishment of a sound "permissible dose" of radiation or uranium depend thereon.

A bibliography of 43 references is included.

MDDC - 1263 Peroxides of Plutonium and Thorium, by D. E. Koshland, Jr., J. C. Kroner, and L. Spector, 15 p., n.d., decl. 9/9/47. (ANL-JJK-14B-28).

From studies on the properties of the peroxides of thorium and plutonium, the following conclusions can be drawn.

Plutonium is in the tetravalent state in the green plutonium peroxide precipitates.

The plutonium peroxide which precipitates from aqueous solutions of sulfuric, nitric, or hydrochloric acids contains approximately three peroxide atoms per atom of plutonium. The ratio of peroxide oxygens to plutonium atoms is slightly greator than three inprecipitates formed in the presence of excess hydrogen peroxide and equal to or slightly less than three in precipitates formed in the presence of excess plutonium. The peroxide content of the wet solid is probably not affected by the temperature at which precipitation occurs from the aqueous solution.

The peroxide oxygens in the compound can be removed by drying at room temperature under reduced pressures.

Two crystal forms of plutonium peroxide have been prepared. One of these is probably a two dimensional hexagonal phase and isomorphous with one of the crystal forms of thorium peroxide. The other may be a cubic phase.

Thorium peroxide precipitates formed in solutions containing low sulfuric acid concentrations have approximately three peroxide oxygens per thorium. As in the case of plutonium, this ratio varies slightly depending on whether the thorium or the hydrogen peroxide is present in excess at the time of precipitation. This precipitate has a two dimensional hexagonal phase which is isomorphous with the corresponding plutonium peroxide.

Thorium peroxide precipitate from 0.3 M sulfuric acid contained two peroxide oxygens per thorium. The crystal structure of this compound may be orthorhombic with four molecules per unit cell.

MDDC - 1264 The Adsorption of Xenon on Charcoals at Room Temperature, by R. A. Lad and T. F. Young, 18 p., August 1, 1945. (CC-3106).

The subject of this report is the ability of charcoal to remove xenon at room temperatures from gaseous mistures, especially from those containing relatively large quantities of helium and small amounts of xenon. Two kinds of experiments were made: (1) adsorption isotherms of xenon were determined on seven charcoals at 25°C, and on three charcoals at 0°C. (2) Measurements were also made of the fraction of (radioactive) xenon removed from a gaseous mixture, consisting chiefly of helium, as it passed through a bed of charcoal.

The following conclusions are made. At 25°C charcoals are effective adsorbents of xenon.

The charcoals differ among themselves in their ability to adsorb xenon. The most effective material investigated is a steam activated product made from coal. It had been activated very much less thoroughly than materials which are used for conventional gas adsorption processes.

Temperature is important. A reduction in temperature of 25°C may double the quantity of xenon held by a charcoal.

Helium is not appreciably adsorbed at 25°C.

Adsorption of xenon from a helium-xenon mixture is rapid. The xenon concentration may be reduced, by the passage of a stream of the mixture through a charcoal bed, to only a small fraction of the concentration which would be attained if equilibrium were established.

MDDC - 1265 Rotary Seal. Four Drawings, Los Alamos Laboratory, 4 p., March 1946. decl. 9/10/47. (LADC-419).

A full scale engineering drawing and material list of a drive assembly for a rotary seal is presented; detailed section drawings of principal parts are attached.

MDDC - 1266 Chemistry of Element 93. II. The Oxidation States of Neptunium in Aqueous Solution, by L. B. Magnusson, J. C. Hindman, and T. J. LaChapelle, 14 p., n.d., decl. 9/7/47. (ANL-WMM-128).

Spectrophotometric titrations of neptunium solutions with oxidizing and reducing agents have been used, together with the isolation of the salt $NaNpO_2(OOCCH_3)_3$ from the solution of the high-test oxidation state obtained, to establish the existence of the +4, +5, and +6 states of neptunium. In contrast to both uranium and plutonium, the +5 state of neptunium has been found to be quite stable in acid solution.

MDDC - 1267 Chemistry of Element 93. VIII. Kinetics and Mechanisms of Aqueous Oxidation-Reduction Reactions of Neptunium, by L. B. Magnusson, J. C. Hindman, and T. J. LaChapelle, 30 p., n.d., decl. 9/8/47. (ANL-WMM-118).

All available data on the rates of reaction of neptunium ions in acid solutions with various oxidants and reductants is summarized. In general, the transitions between Np(III) and Np(IV) and between Np(V) and Np(VI) are rapid whereas the transition between Np(IV) and Np(V) is slow. The rate constant for the reaction Np(IV) + Np(VI)$\rightarrow$2Np(V) in 1.0 M H_2SO_4 at 25°C is 2.15 liters $mole^{-1}$ $minute^{-1}$. The rate constant for the reverse reaction is 5.3×10^{-2} liters $mole^{-1}$ $minute^{-1}$. The oxidation of Np(IV) in bromate solutions is slow and complex. From the bromate oxidation data a value of 27.2 kilocalories/mole was calculated for the activation energy of the reaction Np(IV) + Np(VI)$\rightarrow$2Np(V). A remarkable acceleration of the bromate oxidation is observed in solutions containing hydrofluoric acid. The hydrogen ion dependence of the reduction of Np(V) by Fe(II) indicates the mechanism involves ions of Np(V) and Np(IV) of varying degrees of hydrolysis.

A bibliography is appended.

MDDC - 1268 Combination of Plutonium with Plasma Proteins (Electrophoretic and Chemical Analysis), by J. A. Muntz and E. S. G. Barron, 23 p., January 19, 1947. (CH-3767).

It has been shown that plutonium is bound to constituents of blood serum or plasma and is not ultrafilterable from undialyzed sera to the extent that uranium is ultrafilterable.

When the metal is injected into dogs either in the form of the nitrate or citrate it is carried with proteins present in the β globulin fraction. This was demonstrated by electrophoretic fractionation of dog sera and analysis of the fractions obtained.

Plutonium poisoning in dogs results in an altered plasma protein pattern. Many of the changes are similar to those seen in dogs dying of X-ray injury and the alterations become most profound in the terminal period. Certain differences between the plasma protein pattern of plutonium poisoned dogs and X-ray injured dogs are pointed out.

MDDC - 1269 Effect of Single Dose X-ray to the Nail Fold Area of Human Subjects, by M. Nickson, 5 p., June 20, 1947. (CH-3833).

The nail fold area of the left fourth finger of fifteen subjects was observed before and after a single radiation exposure. The total dose ranged from 200 r to 600 r.

From this brief and incomplete study it appears that radiation exposures of 600 r or less when given as a single dose under the conditions described, produce no constant microscopic or macroscopic reaction. The transitory effects were most often microscopic and consisted of hyperemia of the small terminal vessels and dilatation of vessels visible in this area before and after radiation.

MDDC - 1270 Report of Hand Study, by M. Nickson, 56 p., August 1, 1945, decl. 8/29/47. (CH-3368).

Observations have been made of the hands of 973 laboratory and office personnel. Deviations from normal have been noted and photographs taken. Finger ridge impressions have been made of 1287 individuals of whom 15% showed some abnormality. Capillary counts have been done on 838 individuals. The number of capillaries in a given area of nail fold shows some correlation with possible exposure to radioactive materials. Capillary photographs have been taken of 93 individuals. There is a rough correlation between the morphology of the capillaries and the exposure of the hands of young individuals.

Normal aging tends to produce the same or similar changes. Further capillary studies are necessary to confirm or deny the apparent relationship between hand exposure and increased or prematurely aged terminal capillaries.

Photographs and a bibliography of 119 references are included.

MDDC - 1271 The Clinical Physiology of Dogs Exposed to Daily Total-Body Doses of X-Rays, by C. L. Prosser and M. C. Moore, 80 p., October 1946, decl. 9/9/47. (CH-3658).

Dogs that received 50 r and 40 r and one dog that received 25 r daily, died after accumulating an average of 880 r. Clinically, these animals resembled dogs that received single, acute, lethal doses of X-radiation. They developed a severe leucopenia, showed terminal reversal of hetenophil lymphocyte ratio, and had a mild anemia accompanied by increased plasma volume. They differed from single dose dogs in showing earlier diminutions in food and water intake and earlier weight loss.

Dogs that received 12.5 r, and a young dog that received 25 r daily, accumulated an average of 1262 r and clinically showed a subacute picture in which aplastic anemia was prominent. During the first two months of treatment, leucopenia and anemia developed slowly. There was no change in food and water balance or in body weight until 65-80 per cent of the total dose had been accumulated. The destruction of red cells was accelerated during the last month of life, terminal hemoglobins averaged 3.4 as compared with 7.8 g/100 ml at the higher doses, and mean corpuscular volumes increased.

In both groups, the reduction in counts of granulocytes and erythrocytes was proportional to the accumulated dose. Esoinophils and monocytes apperared to be affected earlier than heterophils. Lymphocyte counts, on the other hand, reached plateaus that indicated a constant recovery time. Sedimentation rates increased by several hundred per cent; this increase did not appear to be dependent upon dose rate.

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Plasma cholesterol increased terminally. No significant changes in plasma calcuim, or phosphorus were found. Alkaline phosphatase increased in the last two weeks of treatment, but acid phosphatase did not show any change. Serum albumin decreased and α_3, α_4 globulin, and β globulin plus fibrinogen increased as after single doses of irradiation.

At autopsy, the acutely killed dogs showed typical hemorrhages, ulcers, and edema. The subcutely killed animals had few hemorrhages but showed edema of the gut and an aplastic bone marrow.

35 references.

MDDC - 1272 The Clinical Physiology of Dogs Exposed to Single Total-Body Doses of X-rays, by C. L. Prosser, E. E. Painter, and M. N. Swift, 210 p., December 1936, decl. 8/29/47. (CH-3738).

The median lethal dose of single exposures of 200 kvp X-rays in the dog is approximately 315 r. During the first several hours after receiving a dose in the lethal range, dogs are lethargic, often have diarrhea, and vomit. Blood pressure, heart rate, and temperature remain relatively constant until 10-15 days after treatment, then heart rate and temperature are elevated and blood pressure depressed until death, three to seven days later. Dogs that survive doses of 250 r, or above, usually show a similar rise in temperature for a few days during the same acute period.

The count of lymphocytes per mm^3 declined rapidly to a minimum at one or two days; maximum reduction of about 95 per cent occurred in non-survivors and nearly as great a reduction occurred in survivors (87 per cent after 200-250 r, 60 per cent after 50 r). Slow recovery began after two to three weeks. Morphological changes ranged from clumping of chromatin to dispersion of nuclear remnants.

The count of heterophils per mm^3 reached a minimum several days later than did the lymphocyte count. In the acute period (12-18 days) heterophils were usually less numerous than lymphocytes. In survivors, however, recovery was more rapid than with lymphocytes. After 50 r a mean reduction of 48 per cent in heterophil count occurred and at 20 r effects were of questionable significance. Eosinophils and monocytes roughly paralleled heterophils in behavior.

The red cell count per mm^3, hemoglobin concentration, and hematocrit declined more slowly than did white cell counts reaching minima of 45 per cent of the control levels, at three and one-half weeks in survivors of 250-350 r. Nonsurvivors died before this time and showed less depression in red count. No significant lowering was detected below 100 r. Recovery required two to three months. Reticulocyte counts fell to less than 0.1 per cent in all dogs at 200 r or higher. On recovery the reticulocyte count of survivors rose above control values for several weeks. Cessation of erythropoiesis is not sufficient to account for the red cell reduction and evidence from pigment excretion and blood volume measurements indicates destruction.

Blood platelets were reduced in number per mm^3 and minimal counts were reached at three to four weeks. Significant reduction occurred at 50 r.

Sedimentation rate increased by 50-70 times as the dogs approached the acute period. Threshold for this increase was 100 r. Recovery to normal sedimentation rates occurred in survivors at about one month after treatment. The rise in sedimentation rate is due partly to the decrease in hematocrit and partly to some factor in the plasma.

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Clotting time increased in nonsurvivors and in survivors of doses of 200 r and higher by two to four times. Greatest lengthening occurred during the acute period and recovery of the survivors was rapid.

Plasma volume, measured as Evans blue space, increased as the total volume of circulating cells decreased and blood volume remained relatively constant. The increase in relative plasma volume was by about 15 per cent. It was calculated that about three weeks after doses of 200 r and higher, 18 to 40 per cent of the original total blood cell mass was destroyed. The rate of disappearance of dye (Evans Blue) from the circulation decreased as the plasma volume increased. Interstitial space as measured by thiocyanate space minus Evans blue space increased in two dogs at 400 r but not in two at 250 r.

Phenol red clearance increased by 20 to 35 per cent prior to the onset of fever. This finding, together with a decrease in blood NPN, maintained urine output and N excretion in the face of reduced intake indicates increased kidney function for a few days prior to the terminal period.

Histamine concentrations in plasma of control dogs averaged 0.05 μg/ml. Determinations at various times after different doses of X-radiation showed no consistent changes in plasma histamine concentration.

Electrocardigrams showed a deepening and broadening of the T wave during the terminal period.

Body weight declined very little during the first seven to ten days after a midlethal dose but thereafter fell rapidly to a minimum of about 80 per cent of control weight in nonsurvivors. Some loss in weight by survivors of doses of 100 r and above also occurred in the ten to fifteen day period. Food and water consumption were usually slightly diminished for one to three days after irradiation and were reduced nearly to zero in the acute "depression" period. Dogs that were restricted in food and water intake to correspond to the intake of irradiated dogs lost less weight even when temperature corrections were made. Metabolic balance data ([Food + Water + Wt_1] - [Urine + Feces + Wt_2] - [Food H_2O + Water] - [Urine + Fecal Water]) also indicate an increase in catabolism after irradiation. The apparent respiratory loss of water was reduced, but by a smaller amount than in starvation.

Fecal output corresponded roughly to food intake, but urine output was diminished much less than was water intake. Nitrogen balance became negative as food consumption was reduced, and in the terminal period nitrogen excretion was relatively undiminished even when N intake was zero. The protein component of the weight loss was about 10 per cent.

Blood NPN declined gradually to 50 to 75 per cent of normal at about ten days; terminally it rose to several hundred per cent in nonsurvivors. Blood urea declined less than total NPN as did "polypeptide" N but both showed the terminal rise. Blood sugar was increased for several days prior to the onset of fever. Excretion of creatine declined gradually in nonsurvivors until the terminal period when it increased.

Plasma protein concentration declined by a few tenths of a gm per cent until terminal period when it rose above the control level; the rise in the acute "depression" period was usually not seen in survivors. At about the time when fever first appeared serum albumin became reduced by about 50 per cent whereas α_3 and β-globulins doubled. At this time injection of bovine albumin caused a small decline in β-globulin but not in α_3-globulin.

Several days prior to the onset of fever, dogs that received doses in the lethal range showed intradermal and subcutaneous hemorrhages; some showed hemorrhages in the mouth and most lost blood from the rectum. After the onset of fever hemorrhages became more extensive and edema was often noted, particularly in the region of neck and mouth. During the last twelve to twenty-four hours of life there were signs of cardiovascular hemorrhages, particularly in lymph nodes, heart, bladder, and intestines. Ulcers appeared in the upper intestine and often in the mouth.

53 references.

MDDC - 1273 X-Ray Study of the Uranium-Oxygen System, by R. E. Rundle, N. C. Baenziger, and A. S. Wilson, 14 p., n.d., decl. 9/3/47.

The uranium-oxygen system has been studied as a function of composition by X-ray diffraction. Several new oxides and transition phases have been revealed, and the structures of most of the uranium oxides have been determined fully or in part.

The phases of the uranium-oxygen system are: (1) Between U and UO, two phases, the metal phase and the cubic monoxide with NaCl structure. (2) Between UO and UO_2 the monoxide and dioxide, with little solid solubility. (3) Between UO_2 and $UO_{2.2}$ or $UO_{2.3}$, one phase with the fluorite structure. The UO_2 spacing decreases as the oxygen content of the phase is increased. The phase with excess oxygen corresponds to UO_2 from which some uranium has been removed at random from the structure. (4) Between $UO_{2.3}$ and U_2O_5, two phases. One phase is $UO_{2.2}$ with disordered fluorite structure, the other phase is U_2O_5, an orthorhombic phase closely related to U_3O_8 in structure. (5) Between U_2O_5 and U_3O_8, one phase. The structure changes continuously with composition. (6) Above U_3O_8 only individual oxides have been examined, but the structure of UO_3 is very similar to that of U_3O_8, and there is preliminary evidence that single phases of intermediate character can be produced.

The structure of UO, UO_2, U_2O_5, and U_3O_8 are described.

This paper summarizes material reported on uranium oxides presented in earlier reports.

MDDC - 1274 The Effects of X-Rays on Rabbits. Part III. The Effects of X-Rays on the Leucocytes of the Rabbit, by G. A. Sacher and N. Perlman, 44 p., December 10, 1946, decl. 9/8/47. (CH-3756).

The quantitative behavior of the circulating heterophils and lymphocytes of rabbits exposed to single X-ray doses was investigated. The dose-response curves (response vs dose at a given time after treatment) show that there is a simple functional relation between dose and amount of depression. An expression is derived which fits the characteristic dose-response curves of heterophils and lymphocytes. Values of the parameters are estimated for both systems at all times of measurement.

The time-response curves (response vs time for a given dose) of heterophils and lymphocytes are discussed. The time-response curves of the heterophils make it necessary to postulate the existence of two types of injury, here called regular and nonregular. The evidence for the existence of these modes is discussed.

Variability of response is investigated in its relation to mean level.

7 references.

MDDC - 1275 The Metabolism of Carrier-Free Fission Products in the Rat, by K. G. Scott, et al., 207 p., n.d., decl. 9/3/47.

The alkaline earths, rare earths, zirconium, and columbium when introduced into the body are deposited primarily in the skeleton, where the average degree of retention of the absorbed radioelements is approximately 50 per cent of the initially absorbed quantity. The retained fractions of these radioelements are eliminated at rates which are less than their rates of radioactive decay with the exception of the 340 day cerium and possibly Sr^{90}. The remaining five longlived radioelements, ruthenium, tellurium, xenon, iodine and cesium do not show any significant degree of localization in the skeleton and

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in addition, there is no very striking deposition in any other of the tissues with the exception of deposition of iodine in the thyroid. The rates of elimination for all of these four radioelements are much greater than their rates of radioactive decay, with the exception of iodine accumulated in the thyroid. In this particular case, the release of accumulated iodine in the thyroid is many times slower than its rate of radioactive decay.

The members of the long-lived fission product group which are absorbed by way of the digestive tract include the alkaline earths, tellurium, iodine, and cesium.

MDDC - 1276 Studies on the Inhalation of Fissionable Materials and Fission Products and Their Subsequent Fate in Rats and Man, by K. G. Scott, et al., 168 p., August 1946. (CH-3590).

The purpose of these experiments was to ascertain the possible hazard resulting from inhalation of fissionable materials and fission products. Aerosols of plutonium, uranium plus fission products, protoactinium, and short-lived fission products obtained from the cyclotron and the Clinton Pile were administered to rats. A Zr^{89} aerosol was administered to one human subject and to rats. Aerosols of the above elements were almost totally retained by the head and lungs immediately after exposure. After four days the lungs contained the largest percentage of these elements. The elements deposited in the head were quickly eliminated via the gastro-intestinal tract. The same avenue of elimination was used by the lungs, but at a slower rate. The small percentage absorbed into the body was primarily deposited in the skeleton after conditions of equilibrium had been established. Radioautographic studies indicate that the site of deposition in the lungs of these materials is in the bronchial passage and the alveolar structures. They are rapidly removed from the bronchial tree, presumably by ciliary action and are very slowly released from the alveoli. No accumulation of any of the radioelements was observed in either blood vessels or lymph nodes.

Charts, diagrams, and photographs are included, and a bibliography is appended.

MDDC - 1277 The Effectiveness of Drugs in Preventing or Alleviating X-Ray Damage, by E. L. Simmons, L. O. Jacobson, N. Pearlman, and C. L. Prosser, 98 p., October 1946. (CH-3329).

The protective and ameliorative properties of a variety of substances following irradiation were investigated in rabbits and mice. Four main groups of chemicals were studied: (1) Physiological saline, (2) substances capable of altering the oxidation-reduction equilibrium of the body, (3) hemopoietic stimulants, and (4) enzyme precursors and activators.

None of the substances tested prevented the drastic immediate fall in leucocyte level that resulted in rabbits after 600 r total body X irradiation.

Physiological saline proved to be the most effective stimulant following irradiation. Ascorbic acid was next in effectiveness, followed by pentnucleotide, although the results with these drugs were not as significant. Many substances produced marked temporary elevations in heterophils during the late recovery period, but these were not maintained and, in fact, were frequently followed by returns to the control level.

Lymphocytes, in general, were less responsive to drug stimulation than heterophils. In no case had lymphocyte counts returned to their pre-irradiation level of 37 days.

MDDC - 1278 Histopathological Studies of Mice Exposed to Fast Neutron Radiation, by R. Snider, 52 p., December 1946. (CH-3730).

Histological observations were made on the following structures of CF_1 male and female mice after exposure to 65n, 96n, and 117n units of fast neutrons: spleen, liver, pancreas, thymus, bone, cartilage, mesenteric lymph node, heart, lung, kidney, bone marrow, adrenal, testis, ovary, stomach, duodenum, ileum, colon, peripheral nerve, autonomic ganglia, and skeletal muscle. The bone marrow, thymus, lymph node, and spleen suffered severe damage, and the intestinal epithelium was damaged to a lesser extent. All these organs had completely recovered by 30 days after the two lower doses. The testis, which was also badly damaged, showed a few signs of repair 30 days after 65n and 96n. All other organs were resistant to irradiation by fast neutrons at these doses. Damage was more severe after the larger doses, but no alterations were characteristic of one dose and not of another. In general, the changes observed following fast neutron irradiation were similar to those described by all workers as following irradiation.

A bibliography is appended.

MDDC - 1279 Acute Radiotoxicity of $(Ba\text{-}La)^{140}$ in Rats and Mice. Part II. Metabolism of $(Ba\text{-}La)^{140}$, by R. H. Snyder, W. E. Kisieleski, D. S. Anthony, and R. D. Finkle, 19 p., June 1946, decl. 9/10/47. (CH-3826).

In these experiments mice and rats were injected intraperitoneally with toxic doses of $(Ba\text{-}La)^{140}$. Absorption was relatively rapid and excretion was considerable during the first day. Mice usually excreted 25 per cent of the injected dose by 12 hours, and rats excreted a comparable amount by 50 hours. This excretion rate was comparable to that reported by Hamilton who found for rats a total excretion, in 4 days, of about 46 per cent Ba^{133} and 25 per cent Ba^{140}. Excretion declined rapidly so that after 6 days, mice excreted 0.4 per cent and rats excreted 0.5 per cent of the injected dose per day. In rats, a little more than twice as much Ba^{140} was excreted in the feces as in the urine.

In mice, about 45 per cent of the injected dose of Ba^{140} was deposited in bone, and in rats, about 60 per cent of the dose was deposited there. In both species, these values represent practically all of the retained Ba^{140}. Absorption and decay curves on soft tissues, however, show that most of the injected La^{140} was present in the spleen, liver, and kidney immediately after injection. Limited data indicated that practically none of the La^{140} formed in bone by Ba^{140} decay left the bone for the soft tissues.

It can be concluded that the excretion and distribution of radiobarium, and the distribution of radiolanthanum at the toxic levels are comparable to those at the tracer levels. No significant variations of barium metabolism with the size of dose were noted in mice. With rats, however, large (lethal) doses were retained more completely by the skeleton than were the lower doses. It is likely that this effect of dose represents a "flooding" of the excretion apparatus and, therefore, is dependent on the amount of inactive barium injected with the Ba^{140}. The authors did not have the opportunity to confirm both the observation and explanation with a larger number of animals.

MDDC - 1280 Distribution of U^{233} in Tissues of Mice following Injection of U^{233} (+6) nitrate by A. Tannenbaum, 8 p., October 1945. (MUC-RSS-563)

The purpose of this investigation was to study the distribution and excretion of U^{233} and to compare the results with those previously obtained with uranium (238) salts.

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Six adult C_3H male mice, weighing about 30 grams were used as experimental animals. The solution contained 300 micrograms of U^{233} per ml. Some of the animals received an intramuscular injection in the right hindleg and others were injected subcutaneously in the interscapular area. The U^{233} was injected at three levels: 1.5 micrograms, 15 micrograms, and 45 micrograms.

Clinically the animals showed no ill effects except for a slight decrease in body weight. There was no ulceration or obvious tissue damage at the site of the injection and no limitation of motion of the leg injected.

The major portion of the injected material is rapidly excreted; only about 10% of the injected U^{233} recovered--regardless of the amount injected, site of injection, or whether the mice were sacrificed at 2 weeks or at 4 weeks. It is probable that at first most of the U^{233} excreted represents elimination from the injection site without intermediate fixation in the tissue, rather than of U^{233} which has been fixed in the tissue and then excreted. By the 4th week, however, on the basis of the amount found in the bladder urine and the G. I. tract, it appears that the excretion is of the order of 1% daily (or less) of the total U^{233} in the body, including that remaining at the injection site.

The bone is the principal site of accumulation and the kidney next in importance. The liver contained only about 1% of the total U^{233} in the body; all other organs contained very small amounts. The blood values were unquestionably lower than those for other tissues studied. The spleen showed a higher concentration of U^{233} than did the liver; it is so small an organ, however, that it accounted for relatively little of the U^{233} in the total body.

With the exception of the kidneys the amount of U^{233} found in any organ was roughly proportional to the amount injected. The mice receiving the 45 microgram dosage showed a greater proportion in the kidneys than did the other animals; this might be expected if the 45 microgram dose produced "chemical" damage to the kidneys. The proportion of U^{233} found in the kidneys of these 2 mice begins to approach the proportion of U found in the kidneys of animals injected with or fed toxic amounts of U nitrate.

The distribution of U^{233} is similar to that of uranium 238. U^{233}, therefore, may be used as a tracer for studies on uranium distribution and excretion. Both accumulate principally in the bone and kidneys, and it may be expected that chemical or radiation damage caused by ordinary uranium and the isotopes thereof would be mainly in these organs.

MDDC - 1281 Szilard-Chalmers Reactions. III. The Enrichment of Iron Activity, by E. R. Tompkins, A. W. Adamson, and R. R. Williams, Jr., 8 p., n.d., decl. 9/10/47.

A Szilard-Chalmers enrichment reaction for Fe activity, employing $K_4Fe(CN)_6.3H_2O$ has been developed. Some 30 per cent of the activity is separable from the inactive compound by carrying on $Al(OH)_3$. With longer bombardments, increasing amounts of inactive Fe are separated with the activity.

MDDC - 1282 The Crystal Structure of NpO_2 and NpO, by W. H. Zachariasen, 5 p., n.d., decl. 9/9/47. (ANL-JJK-14B-22).

NpO_2 and NpO are the only two oxides of neptunium for which crystal structure data are available.

A preparation of neptunium oxide is shown to be NpO_2. The dioxide has the fluorite type of structure with a = 5.425 $\pm$ 0.001A and a calculated density of ρ = 11.11.

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A preparation of neptunium hydride is shown to contain NpO_2 and a phase which probably is NpO. The monoxide has the NaCl-type of structure with a = 5.00±0.01Å and a calculated density of ρ = 13.34.

MDDC - 1283 Crystal Structure Studies of the Systems $KF-UF_4$, $KF-ThF_4$, and $KF-LaF_3$, by W. H. Zachariasen, 22 p., February 9, 1946. (CC-3426).

Detailed studies of the systems $KF-UF_4$, $KF-ThF_4$, and $KF-LaF_3$ show the existence of these phases:

In the $KF-UF_4$ system: KU_6F_{25}, KU_3F_{13}, KU_2F_9, KUF_5, α-K_2UF_6, β-K_2UF_6, α-K_3UF_7, β-K_3UF_7.

In the $KF-ThF_4$ system: KTh_6F_{25}, KTh_2F_9, $KThF_5$, α-K_2ThF_6, β-K_2ThF_6, K_5ThF_9.

In the $KF-LaF_3$ system: α-$KLaF_4$, β-$KLaF_4$.

Lattice dimensions and further information about the crystal structure of the various phases are given.

About one hundred and thirty different chemical preparations were made. The results given represent conclusions drawn from the interpretation of the X-ray diffraction patterns of the numerous chemical preparations. Thermal analysis data were not taken.

Most of the two hundred X-ray diffraction patterns which were taken as part of the present investigation were powder photographs.

MDDC - 1284 Fast Linear Amplifier (Model B-3), Argonne National Laboratory, 1 p., April 18, 1946, decl. 9/10/47. (ANL-HDY-640).

A circuit diagram is given for a fast linear amplifier, using as an input tube, a 6AC7, followed by three more 6AC7's. The amplifier circuit is complete, having its own self-contained power supply.

MDDC - 1285 Linear Amplifier, Model B-1, Model B-4, Argonne National Laboratory, 1 p., n.d., decl. 9/10/47. (ANL-HDY-217).

A circuit diagram is shown for a linear amplifier which is flat to approximately 300 kilocycles per second. The amplifier is complete, containing its own power supply. The amplifier has a 24 step attenuator which has attenuation of 1.25 decibels per step. A 6SJ7 input tube is used followed by a 6AC7, a 6SJ7, and a 6SJ7. The circuit diagram also shows various elements which can be used in the first four amplification stages to make the amplifier flat to approximately 500 kilocycles per second.

MDDC - 1286 Model B-4 Linear Amplifier Amplifier, Argonne National Laboratory, 1 p., n.d., decl. 9/10/47. (ANL-HDY-221).

This report contains the same information as MDDC - 1285, except for the fact that the values given for the amplifier which have a flat frequency response of 300 kilocycles per second are omitted. The values for the amplifier giving a frequency response flat to 500 kilocycles are included.

MDDC - 1287 Triple Pulse Generator (with Variable Decay), Argonne National Laboratory, 1 p., n.d., decl. 9/10/47. (ANL-HDY-218).

A circuit diagram for a triple-pulse generator with a variable decay is shown. A self-contained power supply, one of the pulse generator circuits and the output circuit are indicated.

MDDC - 1288 Two-Fold G. M. Coincidence Unit, Argonne National Laboratory, 1 p., n.d., decl. 9/16/47. (ANL-HDY-223).

A circuit diagram of a 2-volt GM coincidence unit is presented. The separated channels use 6J6 input tubes which then go into another 6J6. The two channels then go together at another 6J6, which after further amplification is available as a coincidence output. The coincidence unit is complete, having its own self-contained power supply. There are three outputs available, a single output from either of the two coincidence preamplifiers or a coincidence output which is activated when the two input signals are simultaneously activated.

MDDC - 1289 Three-Fold G. M. Coincidence Unit, Argonne National Laboratory, 1 p., n.d., decl. 9/16/47. (ANL-HDY-220).

A circuit diagram is set up for a three-fold GM coicidence unit. There are three parts to the circuit diagram: (1) The input circuit is shown for one channel which is identical for the other two. Then the coincidence circuit is shown using 6J6 input tubes. A neon bulb lights up when one of the coincidence input circuits is activated. There are four available outputs, one from the three input circuits, and one coincidence output which is activated only when the three individual input circuits are activated simultaneously. The power supply of the complete unit is also shown.

MDDC - 1290 1500 Volt Supply - Negative or Positive, Argonne National Laboratory, 1 p., n.d., decl. 9/10/47. (ANL-HDY-219).

A circuit diagram for a 1500 volt electronically regulated power supply is laid out. A switch is available to give an output either positive or negative. A 6C6 tube is used for series electronic regulation for which a 45 volt battery is used as a reference.

MDDC - 1291 The Neutron Scattering Cross Section at the Cadmium Resonance, by W. W. Beeman, 4 p., June 19, 1947. (ANL-HDY-252). (See also Physical Review, Vol. 72, p. 986-987, November 15, 1947.)

The scattering cross section at the cadmium resonance was measured using a beam of neutrons from a single crystal monchomator.

The cross section was found to be $40 \pm 15 \times 10^{-24}$ cm^2 referred to the normal isotopic mixture. Approximately half the indicated error is the probable error from the counting statistics. The other half represents an uncertainty in the corrections.

MDDC - 1292 Inelastic Scattering of Fast Neutrons, by S. Bernstein, B. T. Feld, and L. Szilard, 2 p., n.d., decl. 9/10/47.

The authors investigated the trend of inelastic scattering of fast neutrons for a number of elements. As sources, compressed Ra-Be and RaB mixtures were used. The detector was a spherical ionization chamber coated with uranium oxide and surrounded by cadmium, so as to record fissions of U^{238} due to neutrons above the threshold for this reaction (about 1 Mev). The procedure was to measure the fission rate in the chamber first with the source at a given distance from the chamber and, second, with the source at the center of a sphere of the material under investigation and at the same distance from the chamber. Corrections were applied for (1) energy loss of neutrons near the threshold due to elastic scattering; (2) the increase of solid angle subtended by the source for neutrons which suffered elastic collisions in the scattering sphere and (3) the increased neutron path length in the scattering sphere due to elastic scattering. To obtain a check on this correction, the experiment was performed with at least two spheres of different diameter. However, in each case the sphere radius was kept small compared to the neutron mean free path.

The resulting cross sections are given in the following table:

Cross Section for Inelastic Scattering of Ra-Be or Ra-B Neutrons to below the U^{238} Fission Threshold

Element	Atomic Number	σ (barns) Ra-Be	Ra-B
C	6	0	0
Al	13	0.4	0.4
Fe	26	0.9	0.8
Pb	82	1.2	0.9
Bi	83	1.5	1.1

MDDC - 1293 Remote Control Pipette, Prints D2117, D2118, D2119, D2120, E2020, Clinton Laboratories, 5 p., April 1947, decl. 9/16/47.

Drawings are presented for an apparatus to transfer radioactive solutions while the operator remains at a safe distance. A container with lead shielding is provided with openings to accommodate bottles of various sizes. A rubber cup for unscrewing and removing bottle caps is attached, through a train of gears to an arm ending in a knurled knob and attached to a central pivot. A pipette is attached to another arm, swung on the same pivot. The pipette can be raised and lowered with a gear and rack arrangement so that samples can be taken from a positioned bottle. A piston type syringe allows for filling pipette and discharging into another bottle.

MDDC - 1294 The Formula and Structure of Uranyl Ion, by H. W. Crandall, 27 p., n.d., decl. 9/11/47.

Although uranyl ion has been shown to be a doubly positive charged ion in dilute acid solution by previous investigations no evidence has been obtained to distinguish between the two possible ions UO_2^{++} and $U(OH)_4^{++}$

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The exchange of oxygen between uranyl chloride and water has been measured in dilute hydrochloric acid solution using oxygen 18 as a tracer and analyzing with a mass spectrometer constructed by the author. It was found that in 0.1 N to 0.65 N HCl the formula of uranyl ion is UO_2^{++}. The uranyl oxygen bonds are covalent in nature. Further, it was established that UO_2^{++} was a covalently bonded unit in crystalline uranyl chloride.

The Taman spectra of uranyl chloride and uranyl perchlorate was measured. The spectrum of uranyl perchlorate is closely similar to that of uranyl chloride and those of other uranyl salts previously investigated. No positive conclusion with regard to the configuration of uranyl ion in solution was reached. A discussion of the available data is included in the text.

MDDC - 1295 Vapor Pressure, by R. H. Crist and B. Weinstock, 7 p., n.d., decl. 9/25/47. (2R-152).

The vapor pressure of uranium hexafluoride, (UF_6), has been determined from 0°C to 85°C in a copper apparatus. The data obtained are given by the two equations

$$\log_{10} P_{mmHg} = \frac{-2623.3}{T} + 10.8407 \quad \text{(solid, vapor)}$$

$$\log_{10} P_{mmHg} = \frac{-1505.9}{T} + 7.5223 \quad \text{(liquid, vapor)}$$

and the latent heats are:

$$\Delta H_{sub} = 12.00 \text{ kg cal}$$

$$\Delta H_{vap} = 6.89 \text{ kg cal}$$

The experimental arrangement is shown. This consists of a reservoir in a thermostat and a brass sylphon bellows for the measurement of pressure by a null method. The pressure above an atmosphere was read on a multiple mercury manometer using dibutylphthalate as a piston liquid. Data are tabulated and plotted.

MDDC - 1296 A Photoelectric Alpha Particle Detector by S. C. Curran and W. R. Baker, 7 p., November 17, 1944. decl., 9/23/47. (RL 7.6.16). (See also Review of Scientific Instruments, Vol. 19, p. 116, February 1948.)

The combination of a multiplier type photo-cell, such as a 1P21, with the method of scintillations produces a good counting arrangement for the detection of α-rays. The apparatus is satisfactory as regards sensitivity and resolving time and it can count correctly in the presence of strong background radiations. The mechanical features of the device are strongly in its favor. Troubles due to microphony are entirely eliminated, while the circuit is of a simple nature.

A circuit diagram and a geometric arrangement of the instrument are included.

MDDC - 1297 Model 100 Counting Rate Meter, by J. Gallagher and M. Sands, 13, p., October 7, 1946. (LADC-333).

A counting-rate meter is described which provides for the operation of a penwriting device so that a continuous and permanent record of radiation intensity can be obtained. A control of the "averaging time" of electrical damping is provided so that the time necessary for the instrument to reach equilibrium need be no longer than that required for the desired statistical accuracy. This control is calibrated in terms of the statistical probable error in any given instantaneous indication. The instrument also contains a limited device which may be used to operate an alarm system.

A block diagram and a circuit diagram of the instrument are included.

MDDC - 1298 Note on Zero-Zero Transitions, by M. L. Goldberger, 5 p., July 1947. (ANL-HDY-255).

Zero-zero nuclear transitions have been suggested as an explanation of long lived isomers. Stimulated by preliminary results of experiments on the isomeric transition in Ir^{192} (mean life 2.16 min, energy 58 kev), the authors computed the γ-ray energy spectrum and lifetimes for zero-zero transitions in which one electron and one quantum are emitted. For comparison, the lifetime for the transition Og→Og (or Ou→Ou) by direct emission of an electron is computed. The analogous transition in the case Og→Ou is strictly forbidden.

The experimental evidence at the present time is insufficient to draw any definite conclusions in the case of Ir.

MDDC - 1299 Resonance Scattering of Neutrons by Cobalt, by S. P. Harris, A. S. Langsdorf, Jr., and F. G. P. Seidl, 4 p., July 29, 1947. (ANL-HDY-260). (See also Physical Review, Vol. 72, p. 866-867, November 1, 1947.)

The resonance in cobalt was studied near 115 ev and it was concluded that it is predominantly scattering. The results indicate that the resonance cross section is at least 5000 to 6000 barns.

One experiment consisted of measuring the transmission of a cobalt sulphate solution in D_2O(0.0233 gm/cm^2 of Co) for neutrons detected by the activation of the 10.7 minute Co^{60} activity in a thin electrolytic Co metal foil (about 0.01 gm/cm^2 of Co). The detector was 200 cm behind the filter in a well collimated beam from the Argonne heavy water pile. The beam was filtered by a B^{10} plate to remove much of the activation by neutrons below 100 ev. With 0.148 gm/cm^2 of B^{10}, the effective total cross section of Co was 3100 (±500) barns, with 0.313 gm/cm^2 B^{10}, 2700 ± 500 barns. The large error resulted from the weak measured activity which was but a few times background, partly because the softness of the radiations of Co made the G-M counter inefficient.

In the second experiment an annular counter was used to detect neutrons scattered from a beam by a Co foil. The result gives an effective cross section of 2920 ± 150 barns.

A third experiment was also performed in preliminary fashion. The scattering by samples of graphite, manganese, and cobalt inserted into the beam inside the annular chamber were compared, both for the total pile flux including thermal neutrons and for a beam filtered by cadmium. Assuming a constant cross section for carbon of 4.8 barns, the data indicate a large excess of resonance region scattering by Mn and Co relative to their thermal scattering. One may estimate the value of $\sigma_0\Gamma$ for the Co resonance of 10,000 x 10^{-24} cm^2 - ev, neglecting variation of counter efficiency for neutrons of different

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energies, and assuming the excess scattering is all caused by one resonance level. The true value of $\sigma_0\Gamma$ is probably greater than this estimate, which puts a lower limit on Γ of about 1 ev. For Mn $\sigma_0\Gamma$ seems to be somewhat greater than for Co. For Mn a lower limit on Γ is probably near 3 ev. The results are consistent with predominance of scattering in both these resonances.

MDDC - 1300 The Metabolic Degradation of 1,2,5,6-Dibenzanthracene Labeled in the 9-Position with Carbon 14, by C. Heidelberger, 6 p., August 5, 1947. (BC-72).

The metabolism of dibenzanthracene may be studied conveniently when the molecule is labeled with carbon 14. The distribution of radioactivity in the organs and excreta of mice is described. It is now possible to gain considerable insight into the metabolic processes of the animal by chemical fractionation of excreta samples, while following the radioactivity. In feces, only about 4% of the activity excreted is present as dibenzanthracene itself. A large amount of water-soluble activity was observed which indicates extensive degradation of the original substance. Further work should result in the elucidation of the chemical nature of these metabolites.

MDDC - 1301 The Effects of Irradiation from the Atomic Bomb on the Japanese, by J. W. Howland and S. L. Warren, 38 p., August 1947. II-188-7350). (See also Cancer Research, Vol. 6, p. 449-453, 1946)

A brief description is given of the medical effects following the atomic explosions at Hiroshima and Nagasaki. A discussion of the immediate clinical human pathology resulting from blast and burns is included. The effects of acute whole body irradiation on the human are considered in detail as well as pertinent observations on living individuals observed one year later. The comparative clinical and pathological effects of whole body irradiation on animals are given briefly. The pathological findings on tissues sensitive to irradiation namely lymphatic system, bone marrow, gastrointestinal canal and gonads are discussed.

Photographs are included.

MDDC - 1302 Nuclear Engineering Basic Design Background, by J. R. Huffman, 16 p., n.d., decl. 9/29/47. (See also Chemical Engineering, Vol. 55, p. 117, January 1948.)

The applications of nuclear physics and radiochemistry in recent years have led to the emergence of a new specialization in engineering. This paper, which was given as a talk, presents the scope of nuclear engineering and points out new concepts and unique features which particularly characterize the field. A few simplified specific problems are discussed in order to emphasize these new ideas.

MDDC - 1303 A Method of Assay for C^{14}, by C. D. Janney and B. J. Moyer, 24 p., July 31, 1947. (BP-102).

The design and use of apparatus for the measurement of amounts of C^{14} down to a specific activity of the order of 10^{-9} curie per gram is described. Use is made of an ionization chamber containing the sample to be analyzed (as CO_2) and a Lindemann electrometer. The auxiliary electrometer circuits and the apparatus for handling the CO_2 gas are also presented. The method has been used in the Radiation Laboratory for the routine analysis of samples obtained from biological tracer experiments. A comparison with other methods of C^{14} detection is included.

With present technique, filling the chambers requires somewhat longer than making $BaCO_3$ plates for the thin window counter, but the sensitivity for total activity is 10 times greater, and that for specific activity (if sufficient sample is available to fill the ion chamber without further dilution) is 50 times greater than for the mica window counter. Further increase in sensitivity can be obtained by using a recording electrometer and subtracting out alpha particle ionization.

Circuit diagrams and a photograph of the apparatus are included.

MDDC - 1304 Some Engineering and Economic Aspects of Nuclear Energy, by M. C. Leverett, 23 p., August 14, 1947.

The author presents some ideas about nuclear power as it now appears to some of the engineers and scientists working in this field.

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The topics are discussed briefly and include: the chain reaction, supply of fissile materials, engineering problems, materials of construction, moderators, fuel element design, shielding, control, economic considerations, and future developments in nuclear power.

The author concludes that primarily because of cost nuclear power is pretty much eliminated from the automotive field and from use in place of coal, but may be used in isolated applications where coal is extremely costly. First practical applications of nuclear power plants will most likely be on shipboard.

MDDC - 1305 Collision Mechanics and Energy - Angle Nomographs, by J. L. McKibben, n.d., 16 p., decl. 9/12/47.

The general reaction of interest in nuclear physics is that due to M_1 colliding with M_2 and producing M_3 and M_4 with reaction energy Q. It is shown that the energies of M_3 and M_4 can be obtained at any angle from a nomograph simply constructed of semicircles. General formulae for the calculation of these energies and the related solid angle transformations are derived in several of the simpler forms. Nomographs are given for $Li^7(p,n)Be^7$, $D(d,n)He^3$, $He^3(d,n)He^4$, $H^3(p,n)He^3$, and $C^{12}(d,n)N^{13}$ reactions.

MDDC - 1306 Excitation Curve for the Reaction $C^{12}(p,pn)$ up to 140 Mev, by E. M. McMillan, 6 p., n.d., decl. 9/23/47. (BP-104). (See also Physical Review, Vol. 72, p. 873-874, November 1, 1947.)

The excitation curve for the above reaction was obtained by measuring the activities of carbon plates traversed by high energy protons from the 184" cyclotron. The activation starts at 20 Mev, rises rapidly to 7/8 of its final value at 40 Mev, then slowly to a constant value at 60 Mev, where it remains up to 140 Mev.

A schematic diagram of the experimental setup in the 184" cyclotron is included.

An excitation curve for the C^{11} activity induced in carbon plates by protons is also presented.

MDDC - 1307 The Outgassing of Materials in a Vacuum, by G. W. Monk, 7 p., n.d., decl. 9/12/47.

An apparatus is described which can be used to measure the loss in weight of a sample in a vacuum (0.01 microns) at temperatures up to about 700°C. The apparatus consists of a chemical balance which is operated electrically while the balance and sample are both under vacuum. A diagram of the equipment is presented.

Typical preliminary results are given for aluminum, carbon, and "Teflon".

There are many other applications of this type of equipment since it is rugged and easily operated. Absolute pressure measurements can be made by directly measuring the force between the hot and cold plates in a Knudsen type gage. The rate of flow of gases and vapors under very low pressures can be obtained by measuring the difference in pressure on the ends of a cylinder suspended in the stream. The vapor pressure of a great many materials could be studied at high temperatures by observing their rate of loss of weight per unit area.

MDDC - 1308 An Apparatus to Facilitate Intravenous Injections in the Mouse, by J. J. Nickson and S. S. Barkulis, 4 p., July 9, 1947. (ANL-4009).

A method of transillumination of the tail vein is described and results in using it for intravenous injections are presented.

The equipment consists of a box, a lamp, a hand lens, and a mouse holder with a lucite base. The mouse is held in the holder, the tail is held by a clip on the box, and the operator holds the tail at the distal end to keep it taut for easy penetration of the needle. A microscope lamp illuminates the lucite and the light transilluminates the tail.

There are four veins in the tail of the mouse, two lateral, a dorsal and a ventral. Four fibrocartilaginous bands radiate out from the core of the tail to separate the veins.

If the needle is introduced into the vein, injection will be easy and the whole column of blood in the vein proximal to the needle will be replaced by the injectate. When the needle is pulled out, a small amount of liquid will appear at the site of needle penetration. One-half inch, No. 27 needles were found most suitable.

It was possible after a few days practice with this method to inject the tail vein successfully 90-95 per cent of the time. The authors were able to give at least 22 intravenous injections in the tail veins of 150 mice over a period of 11 weeks so that at the end of this time the majority of the tails were free of venous sclerosis.

A diagram and a photograph of the apparatus are included.

MDDC - 1309 A Study of the Hands of Radiologists, by M. Nickson, 34 p., June 1, 1947. (CH-3831).

A group of radiologists was studied for evidences of radiation damage to the skin of their hands. The technics used consisted of (1) examination of wax impressions of the finger ridges, and (2) examination of photographs of the vessels and papillae in the nail fold.

Of the 323 radiologists examined by the first method 48% were found to have ridge abnormalities. The incidence of abnormality increased with years of exposure to radiation up to 100% after 35 years. The irregular use of lead gloves does not give adequate protection against damage of the ridges by radiations.

Photographs of the nail fold of 152 radiologists were studied and compared to similar photographs of 101 laboratory workers and of 41 persons over 63 years of age. Some of the abnormalities occurred in all 3 groups. All of the changes which were found among the radiologists were found also in the aged. The incidence of abnormality among the radiologists increased with years of exposure to radiation and exceeded the incidence of abnormality in the aged. No radiologist had normal findings after 30 years of exposure. It is concluded that abnormalities of the vessels and of the papillae in the nail fold are induced earlier in radiologists than in persons not exposed to radiation.

Tables and photographs are included.

MDDC - 1310 Drift Tube Design in Linear Proton Accelerator, by F. Oppenheimer, 8 p., June 27, 1946. (BP-8).

In the proposed accelerator, protons are to be accelerated down the axis of a resonant cavity, and shielded from the reversed electric field every half cycle, by passing through "drift tubes." The protons will gain an energy

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$$V = V_{max} \frac{\sin \pi\alpha}{\pi\alpha}$$

where α is the fraction of the cycle during which the particles are not in a field free region. Since V has a maximum for $\alpha = 0$, the criterion for the length of the accelerating gap is that the field strength between drift tubes not be too great. A value of $\alpha = 0.25$ was chosen as a reasonable compromise and the shapes of drift tubes which satisfy this condition were investigated.

The proposed accelerating system may be considered as a number of coaxial reentrant cylindrical cavities placed in line, with the conducting planes normal to the axis removed. The lengths of these equivalent cavities will vary with the particle energy, and will equal $\beta\lambda$. Variable model cavities at 3000 megacycles were made to investigate the relationship between drift tube diameter, α and β, for constant frequency, f, and constant outside cavity diameter, D. An approximately linear relationship was found between drift tube diameter and β, at constant, α, f, and D, for β between .09 and .3. Details of these measurements and other considerations of drift tube design are given.

MDDC - 1311 The Exact Masses of the Zirconium Isotopes, by W. Rall, 4 p., June 24, 1946. (ANL-AJD-183).

The packing fraction of the zirconium isotopes was found by comparison with uranium 238. This was done by deduction from photographs of the doubly charged zirconium masses which appear with the apparent masses 45, 45.5, 46, 47, and 48 and superimposing these on quintuply charged uranium ions near mass 47.6. The difference is $(12.1 \pm 0.9) \times 10^{-4}$. Using the published value for uranium of 5.6×10^{-4}, the zirconium packing fraction comes to be -6.5×10^{-4}. There appears to be no specially large binding energy for the zirconium nuclei which might be called on to explain the high yield of these products in fission.

MDDC - 1312 Development of the Frequency Modulated Cyclotron, by J. R. Richardson, B. T. Wright, E. J. Lofgren, and B. Peters, 28 p., n.d., decl. 9/16/47. (BP-99). (See also Physical Review, Vol. 73, p. 424-436, March 1, 1948.)

The experimental development of the phase stability principle as applied to the 37 inch FM cyclotron is discussed. The ions were required to pass through an overall radial decrease in magnetic field of 13 per cent. Some theoretical estimates of the yield vs modulation frequency are given and these were found to be in satisfactory agreement with the experimental results. It is found that some of the ions emerge as late as four or five modulation cycles after their initial acceleration. Observations were made of the time of flight of the ions and evidence was found of the actual phase oscillations in the shape of the ion current patterns. The ion current received by a probe at different radii and different pressures using a pulsed source was analyzed, and indicates a considerable loss of beam at dee voltages less than 60 kev. The data confirm the variation of ion beam loss as the reciprocal of the square of the ion energy and extend the validity of this relation to 600 kev for deuterons. The variation of ion current with dee voltage is quite steep. A deflected beam amounting to 10% of the circulating current was obtained, taking advantage of the precessional motion of the ion orbits. Circulating ion currents of 3 μa of 7.5 Mev deuterons and 2 μa of 14.6 Mev protons was obtained.

Photographs are included.

MDDC - 1313 The Charge Distribution in Nuclei and the Scattering of High Energy Electrons, by M. E. Rose, 12 p., n.d., decl. 9/12/47. (MonP-346). (See also Physical Review, Vol. 73, p. 279-284, February 15, 1948.)

It is pointed out that the finite size of the nucleus will give rise to large deviations from Mott scattering when the change in wavelength of the electrons is of the order of the nuclear dimensions. This deviation from Mott scattering at large scattering angles therefore provides a possibility for determination of the shape of the charge distribution and size of nuclei. In the case of a spherically symmetric charge distribution the nuclear charge density is immediately obtained from the observed angular distribution by a Fourier transform. The effects of competing processes, inelastic collisions with nuclear excitation or disintegration, atomic excitation or ionization and bremsstrahlung are considered. It is shown that the first two competing effects may be disregarded if the electron energy is in the neighborhood of 50 Mev, the angle of scattering large (but not near π) and if the scattered electron has an energy equal to or nearly equal to the primary energy. With the latter condition fulfilled, the bremsstrahlung is reduced by the same factor as the elastic scattering and the two processes are indistinguishable.

MDDC - 1314 Colorimetric Determination of Uranium with l-Ascorbic Acid, by C. D. Rothenberger, E. F. Orlemann, W. R. Grimes, and C. E. Larson, 2 p., n.d., decl. 9/15/47. (H-WRG-16-2).

The complete text of this document is reproduced below.

A stable, yellow-brown color is produced by addition of l-ascorbic acid to weakly acid solutions of hexavalent uranium.

In 50 ml of solution containing 0.5 to 15 mg of uranium buffered at pH = 4.0 with acetate ion the color intensity, measured with 10 mm cells on the Beckman spectrophotometer set at 410 millimicrons, is a linear function of uranium concentration. The method may be applied directly to suitable solutions containing 25 to 1500 mg uranium per liter. The reagent blank is reproducible and small but not negligible.

Chloride, nitrate, and perchlorate ions are without effect on the color. Phosphate, sulfate, fluoride, and the anions of dibasic organic acids interfere. Compounds of chromium, vanadium, nickel, zinc, molybdenum, and aluminum interfere, while those of iron, cadmium, magnesium, calcium, tin, manganese, and thorium are without appreciable effect on the color. Addition of pyridine with the buffer solutions prevents interference of cupric ion.

Diethyl ether extraction of uranium from aqueous acid solutions containing calcium nitrate provides a very rapid and effective purification of uranium for this colorimetric method.

The combined purification and colorimetric method may be applied within sixty to seventy minutes to contaminated uranium solutions to yield results accurate to $\pm 2\%$.

MDDC - 1315 Air Proportional Alpha Counters, by J. A. Simpson, Jr., 29 p., October 8, 1945. (CP-2851).

This report introduces the use of proportional counters, in which the ionizing gas is air at atmospheric pressure, as the basis for the development of a series of radiation detection and measuring instruments.

Interesting properties of this counter and various counter designs are discussed under the following headings: air as a gas mixture for detecting ionizing events; discharge mechanism in air; input circuit and amplifier characteristics; design of air proportional counters; windows for atmospheric pressure counters; calibration of alpha survey probes.

Illustrations of the following are presented: effect of atmospheric pressure on counter threshold, temperature characteristic of air counter, alpha survey counter, small alpha survey counter, large window alpha counter, cylindrical air counter, effect of capacity on counter characteristics, topographical variations of sensitivity, nose alpha probe, nylon film window characteristics, probe calibration standard, symmetrical alpha probe, end window alpha counter, and improved narrow alpha probe.

MDDC - 1316 Air Proportional Alpha Hand Counter, by J. A. Simpson and J. Brewer, 33 p., October 8, 1945. (CP-2852).

An air proportional alpha hand counter system which measures the possible existence of alpha contamination on the hands of a person working with radioactive materials is described. It is composed of two counters facing each other and having two 5" x 10" sensitive areas for alpha particles. These two units are mounted on a frame so that any size of hand can be inserted between the two vertical units. The alpha pulses are detected and measured by an electronic unit. The two counters press against the hand so as to present almost the same geometry for all sizes of hands. These counters are connected to the electronic circuit by two cables. On the front panel is mounted a meter, calibrated in logarithmic scale, showing the activity in terms of the number of alpha particles entering through the two 5" x 10" windows. The assembly operates on 110 volt a.c. and has been designed for continuous operation.

The appendix is concerned with proportional counter calibration, assembly of an air proportional counter parts list, center wires, production of aquadag-coated nylon windows, contamination and counter repair, and calibration and adjustment for the electronic unit.

Photographs and circuit diagrams are included.

MDDC - 1317 Low Absorption Neutron Proportional Counter, by J. A. Simpson, Jr., 10 p., September 18, 1945. (CP-3141).

The counter described was developed for use in making direct measurements of impurities in a uranium sample by a comparison with standard impure samples.

The counter is composed of three 2-mil platinum wires parallel to each other and lying in a plane on either side of which is a flat cathode surface. These flat surfaces are made of aluminum coated one inch discs of boron or B^{10} isotope on their inside faces. The coating thickness is about 4 microns. The B^{10} can capture a slow neutron to form a compound nucleus which then disintegrates into a Li^{7} atom plus an alpha particle with some energy. It is this alpha particle which is detected. By making

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the distance between center-wires about twice the distance between a center-wire and a cathode surface, it is possible to obtain a field distribution such that the counter alpha counting yield from any portion of the boron surface is almost constant.

Photographs and circuit diagrams are included.

MDDC - 1318 Initial Studies of the Inhalation Toxicity of Beryllium Sulfate and Beryllium Metal Fume, by G. F. Sprague, C. W. LaBelle, A. G. Pettengill, and H. E. Stokinger, 30 p., August 1947. (II-188-7301).

Data from 56 animals were collected to supply information relevant to the poisonous effects, including the organs injured and the route of the damage, caused by the inhalation of beryllium sulfate tetrahydrate dust at a concentration approximating 90 mg of the salt per cubic meter of air. Six criteria of toxicity were utilized in evaluating the information obtained from the animals which comprised 2 dogs, 3 rabbits, 10 rats, 14 guinea pigs, 20 mice and 7 hamsters. The animals were exposed 6 hours daily for a two-week period, a total of 66 hours, to a dust of this soluble beryllium salt in a small inhalation exposure chamber.

Mortality for all species dying as a result of exposure was 43% of the 56 exposed animals or 20 of 20 mice, 2 of 10 rats, and 2 of 7 hamsters. The mice died from the 3rd to the 11th calendar day with an LD_{50} being attained on the 7th day following the start of exposure. No deaths occurred among the dogs, rabbits, or guinea pigs. Weight response data showed that all species except the guinea pig were adversely affected. The rabbit lost 5% in weight, whereas the rat and hamster lost 11%. Clinical chemical values indicated renal impairment and some subsequent regeneration in the rabbits. Much less serious kidney damage and hepatic injury in dogs was indicated from many chemical tests which included frequent analyses of the blood for sugar, NPN, urea nitrogen, amino acid nitrogen, bromsulfalein and serum protein. All of the urinary variables including amino acid nitrogen/creatinine ratio, sugar and protein were normal at all times. Hematologic results showed definite upward trends in the leukocytic count, notable the absolute neutrophil counts of the dogs, rats and rabbits during the second week of exposure. The other cellular blood elements gave no characteristic trend for any of the species. External symptoms varied somewhat with the species. Ocular opacity developed in the guinea pig, mouse and dog following 12 hours of exposure. Cutaneous lesions of varying size developed over the body of the dog, while the rats were found to have rales. The hamsters and rabbits manifested no external signs of beryllium damage. The histological findings showed the effect of absorption of beryllium sulfate tetrahydrate through the respiratory tract of the mouse, rabbit and rat to be pulmonary damage especially edema. This was not the type of injury, however, found in man. Additional lung lesions observed included inflammatory exudate in the lumina of the terminal bronchi and some foci of atelectasis of the rabbit, hemorrhage of the alveolar sacs of the hamster, and infiltration of neutrophils and monocytes in the lungs of rat. Hepatic injury was observed in mice dying during the first 9 days, but no lesions were noted thereafter, indicating rapid regeneration. Renal changes were found in the rabbit and rat but some regeneration of the tubular epithelium was observed in the rabbit kidneys.

Marked species variation, but unusually good conformity within each species, was thus observed in the response to the inhalation of $BeSO_4 \cdot 4H_2O$. The sulfate ion, conferring a high acidity upon the molecule as a whole (with an approximate pH of 1.0 for the saturated solution), was felt to contribute significantly to the toxicity of the beryllium salt.

Rats have been exposed by inhalation to beryllium metal fume at an approximate concentration of 800 mg/m^3 of air under a variety of exposure schedules to determine the character of the toxic response.

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Seven of 10 rats died of pulmonary hemorrhage following exposure to 24,000 CT units of fume administered as eight exposures of from 3 to 4 minutes each over a period of two hours. When the exposure was one-half this value, or 12,000 CT units, no rats died or showed other untoward response. Moreover, rats were found to tolerate 200,000 CT units or nearly 10 times the lethal dosage if administration of the fume was made at the rate of 4,000 units daily for a period of 60 days. Some reduction in growth rate, however, was noted on this schedule.

It was concluded that beryllium metal fume acts as a primary irritant which, when administered rapidly in high dosage, may be fatal but which is tolerated relatively well as long as no single dose exceeds 12,000 CT units. No cumulative poisonous effects were seen.

MDDC - 1319 The Effects of Total Body X-Irradiation on the Peripheral Blood and Blood Forming Tissues of the Rat, by S. P. Stearner, E. L. Simmons, and L. O. Jacobson, 66 p., April 7, 1947. (ANL-4001).

Following exposure to single doses of 300 r and 600 r, a maximum anemia developed after 14-16 days. Recovery was complete at 30 days following 300 r, but a significant difference persisted until 94 days between control animals and those exposed to 600 r. Histological study of the bone marrow after exposure to 600 r revealed a completely aplastic condition for 7-9 days following irradiation, but by 14 days a hyperplastic condition was present. The relatively long life of the red cell (20-30 days) may explain the delayed appearance of the effects of irradiation on the circulating erythrocytes. A macrocytic anemia was demonstrated by the presence of an increased mean corpuscular volume and mean erythrocyte diameter. The white blood elements showed a maximum depression three days after X irradiation. Recovery began 10 days after exposure to 300 r and 600 r, and was essentially complete at 30 days. After 25 r there was a very small decrease in number of circulating leucocytes and recovery was complete by 14 days. Exposure to 300 r and 600 r produced drastic effects on heterophils as well as lymphocytes. Damage was seen in the lymphatic tissue as early as 1/2 hour following 600 r X-irradiation. The completely aplastic condition, present at two days, persisted until about the ninth day, at which time regeneration began. This corresponds to the first increase in number of circulating cells. A large amount of regenerating lymphatic tissue was present two weeks following irradiation, and active nodules were seen. At 35 days, regeneration was complete but it appeared that, compared with the controls, fewer cells were present per unit area. The time of degeneration and regeneration of granulopoietic tissue corresponded closely to the decrease and increase in number of circulating cells. The relation between the number of leucocytes in the circulating blood and the condition of the tissue in which they are formed indicate a short life span for these cells. This is in accord with previous estimates.

Exposure to daily X-ray doses of 33.5 r resulted in a total of 3080 r and a maximum survival of three months. This dose rate produced only a slight depression in hemoglobin and erythrocyte values and a small decrease in number of circulating heterophils. However, lymphocytes were reduced after one week of treatment and fell continually until the death of the animals. A dose rate of 7.7 r per day was not shown to shorten the life span of the rats and had a doubtful effect on the circulating erythrocytes. The number of circulating heterophils was not decreased, but lymphocytes were reduced after one month of daily exposure and remained at a low level. Exposure to 7.7 r for over 8 months could not be shown to have produced any change in the blood forming organs.

A comparison of the effects of X-irradiation on the peripheral blood of rats and rabbits showed that the pattern of response was very similar in the two species and that only minor differences were present. The response of the peripheral blood cells to daily doses of X-rays indicated that the effects upon lymphopoietic tissue were much greater than upon the elements formed in the bone marrow (heterophils and erythrocytes). A bibliography and photographs are included.

MDDC - 1320 **Excitation Curves for the Reactions $C^{12}(d,dn)C^{11}$ and $C^{12}(\alpha,\alpha n)C^{11}$ at High Energies, by R. L. Thornton and R. W. Senseman, 4 p., August 12, 1947. (BP-113). (See also Physical Review, Vol. 72, p. 872-873, November 1, 1947.)**

The complete text of the report is reproduced below.

The energy dependence of the reactions $C^{12}(d,dn)C^{11}$ and $C^{12}(\alpha,\alpha n)C^{11}$ has been investigated to energies of 195 and 390 Mev, respectively. The usual technique was employed of bombarding a stack of plates of pure graphite of total thickness sufficient to contain the range of the deuterons or alpha particles and determining the induced C^{11} activity (20.5 min) of the individual plates. The ion beam of the 184-inch cyclotron was deflected inward by a pulsed electrostatic deflector of angular length about 120 degrees. The deflected beam reaches its maximum radius 360 degrees from the start of the deflector and there has an increase in radius of two to three inches. The deflected beam is incident on the stack of plates which was mounted in a lead shielded box on the end of the target probe and could be withdrawn through a vacuum lock. The ion beam was defined by a window in a lead plate one inch thick immediately in front of the graphite plates. Experiment showed that the overlap of the plates over the window opening was sufficient to contain the beam within the area of the plates. Plates of both 1/4 and 1/16 inch thickness were used simultaneously in determining the excitation curve. The majority of the thin plates were used in the region where the curve was changing most rapidly, but others were interspersed between 1/4 inch plates at other points. Since for the same current and energy the thin plates gave lower activity, it was necessary to adjust the two resulting curves. This was done by multiplying the measured activities of the thin plates by a factor which would bring the curves into coincidence at high energy region where the excitation curve was found to be slowly varying.

The radioactive decay curves of the plates show an exponential decay of period corresponding to C^{11}. In the case of deuteron activation, an indication was observed of a shorter period on plates near the end of the deuteron range. This is presumably due to the reaction $C^{12}(d,n)N^{13}$ which, however, was not observed at higher energies. Residual activity is observed at thicknesses greater than the range of the ions. This is due to fast neutron activation by the (n,2n) reaction; in the alpha particle curve additional background arises from the deuteron contamination of the ion beam.

In neither curve is there apparent a tendency for the yield to fall off at high energies due to the increasing probability of more complicated competing reactions. This would suggest that the maximum energy of the incident particle is not in general available for such reactions, but that it is more probable that only a fraction of this energy is transferred to the nucleus. Experiments with elements of higher atomic number, and the frequent production of stars, show clearly that the probability of the emission of many nucleons is significant.

MDDC - 1321 **The Preparation of C^{14} Methyl Labeled Sodium Acetate, by B. M. Tolbert, 4 p., August 15, 1947. (BC-76). (See also Journal of Biological Chemistry, Vol. 173, p 205-206, March 1948.)**

Sodium acetate labeled in the methyl group with C^{14} has been prepared from methyl iodide on a 15 to 25 millimole scale by carbonating methyl magnesium iodide.

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The several steps of the preparation are:

1) $C^{14}H_3I + Mg \rightarrow C^{14}H_3MgI$ — 100%

2) $C^{14}H_3MgI + CO_2 \rightarrow C^{14}H_3CO_2MgI$

3) $C^{14}H_3CO_2MgI \xrightarrow{H^+} C^{14}H_3CO_2H$ — 70-75%

4) $C^{14}H_3CO_2H \xrightarrow{OH^-} C^{14}H_3CO_2Na$ — 100%

A diagram of the apparatus is included.

MDDC - 1322 A Kinetic Study of the Oxidation of Uranium Tetrachloride, by J. Van Wazer and G. John, 5 p., n.d., decl. 9/24/47. (See also Journal of the American Chemical Society, Vol. 70, p. 1207-1209, March 1948.)

A novel method for kinetic studies of solid-gas reactions in which the solid undergoes a color change has been used for determining the activation energy for oxidation of uranium tetrachloride. The oxidation process consists of two independent steps which can be described by the following equation:

(1) UCl_4 (green) + $O_2 \rightarrow UO_2Cl_2$ (yellow) + Cl_2

(2) $3UO_2Cl_2$ (yellow) + $O_2 \rightarrow U_3O_8$ (black) + $3Cl_2$

There is also a side reaction in which the uranium tetrachloride reacts with the chlorine evolved to form volatile uranium pentachloride.

MDDC - 1323 Methods of Driving a High Q Cavity with Many Self-Excited Oscillators, by J. R. Woodyard, E. A. Martinelli, W. Toulis, and W. K. H. Panofsky, 5 p., June 20, 1946, decl. 9/26/47. (BP-2a).

The problem considered is that of driving a long cavity resonator to be used as a linear accelerator, in the lowest longitudinal electric mode, by means of a large number of oscillators. Special problems are encountered when the resonator is many wavelengths long and the field is to be without nodes as is the case here. Additional questions of oscillator buildup are introduced because the oscillators are pulsed. By properly loading each oscillator it was found that synchronization could easily be made to occur over a comparatively large range of tuning, and that the electric field strength in the cavity resonator increased with the square root of the number of driving oscillators.

MDDC - 1324 **Effects of Space Charge on the Detection of High Energy Particles by Means of Silver Chloride Crystal Counters, by L. F. Wouters and R. S. Christian, 2 p., July 28, 1947, decl. 9/26/47. (BP-105). (See also Physical Review, Vol. 72, p. 1127-1128, December 1, 1947.)**

Silver Chloride crystals are being used for the detection of high energy protons produced in the 184-inch cyclotron neutron beam. The principal difficulty lies in a gradual decrease in observed pulse height as counting proceeds due to neutralization of the electric field within the crystal by accumulated space charge. It is found possible to circumvent this effect by reversing the polarity of the applied potential at a rate sufficient to make the decrease in pulse height per counting period entirely negligible.

MDDC - 1325 **The Production of Radioactive Xenon for Animal Exposures, by R. Abrams, C. E. Beilman, and L. D. Norris, 59 p., November 26, 1945. (CH-3354).**

Large amounts of Xe^{133} were needed to study the biological effects resulting from inhalation of radioactive gases. This paper deals with the problems of collecting and concentrating Xe^{133} and with the problem of separating it from the uranium matrix after fission.

Because of its chemical inertness, the collection of Xe must involve physical methods. Only adsorption is considered here, and a procedure was adopted whereby the Xe was adsorbed on coconut charcoal at -80°C.

Although the most obvious source of Xe^{133} was the gas given off when pile uranium was dissolved in nitric acid, the source presented a number of difficulties the most obvious of which were removal of nitrogen oxides and provision of adequate shielding. Two diffusion methods were worked out which were shown to be capable of supplying Xe without an expensive plant. Diffusion from finely ground U_3C_8 at temperatures around 1000°C would be successful, provided an adequate container for the oxide could be found. Diffusion at low temperatures can be employed with compounds of high internal surface. $U(CH)_4$, for example, was very active in this respect, but unfortunately slowly lost its emanating power on standing at pile temperatures. A coprecipitate of ammonium uranate with thorium hydroxide successfully resisted aging for 100 days.

A bibliography of 18 references is appended.

MDDC - 1326 **Acute Radiotoxicity of Injected Cerium^{144} in the Rat, by D. S. Anthony and K. A. Lathrop, 25 p., June 1947, decl. 9/19/47. (CH-3824).**

Groups of 10 or more rats were given doses of 10, 7, 5, 3, and 2 μc of $(Ce\text{-}Pr)^{144}$ per gram of body weight by intravenous injection. The metabolism of the Ce was studied and the effect of this radioactive material on the general clinical condition, survival time, and weight was observed.

At no time was the excretion of cerium rapid, and in fact, it required approximately 35 days for the rats to excrete half of the injected dose. The rate of excretion of Ce^{144} in the urine fell continuously with time, while the rate of excretion in the feces rose to a maximum at about one week and then dropped with time. The ratio of the amount excreted in the urine to that in the feces fell continuously with time.

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The early retention of Ce^{144} was largely in the liver but this dropped rapidly with time. Apparently, some of the radiocerium released by the liver was taken up by the skeleton since the activity of the bones rose to a maximum during the period when the liver was rapidly losing its cerium. As the liver became exhausted of Ce, the activity in the skeleton dropped with time.

The rats that died within the first 30 to 40 days showed an almost complete lack of gross lesions which are usually noted in radiotoxicity studies. In 4 of the 6 animals that died between 70 and 120 days after injection, there was abundant visible evidence of radiation injury to the liver. In a few animals dying at still later times, osteogenic sarcomas were found.

The 30 day LD_{50} for intravenously injected Ce^{144} in the rat was found to be about 3 μc/g of body weight. By 120 days, the LD_{50} was down to between 2 and 3 μc/g.

At all dose levels there was a diminution of the growth rate as measured by increase in body weight.

MDDC - 1327 Theory and Operation of a Philips Ion Gauge Type Discharge, by J. Backus, 40 p., n.d., decl. 9/17/47. (BP-27).

An approach to the problem of arc hash (electrical fluctuations in an arc) has been made from studies of a plasma in a strong magnetic field. These studies were made with a Philips Ion Gauge type discharge, the nature of which is discussed in some detail. On the basis of the results obtained, a theory to account for the hash occurring in such a discharge is proposed, which states that the low voltage discharge is a condition in which the electrons are liberated from the cathode thermionically and that positive ions bombarding the cathode will liberate secondary electrons in insufficient number at low voltages to maintain the discharge, but if the surface of the cathode is heated sufficiently by this bombardment it can then liberate thermionically enough electrons to maintain the discharge. This explains both the fall in voltage after the discharge has been started and the property of the discharge to run in a narrow line down the axis of the PIG, the center of the cathodes running hottest. This low voltage discharge is quite stable under the proper conditions; most of the instability is due to the formation of cathode sports which give a very low voltage discharge (< 50 v) but are very erratic and uncontrollable.

Studies of various types of cathode materials are reported.

MDDC - 1328 Recent Nuclear Data, by G. E. Boyd, et al., 57 p., June 5, 1947, decl. 9/26/48. (MonP-304).

A digest containing nuclear data has been compiled from project reports and non-project periodicals which became available during the period September 1, 1946 to April 1, 1947. Data on abundances, half-lives, production, disintegration energies, energy levels, spins, magnetic moments, quadrupole moments, and cross sections are included.

MDDC - 1329 Determination of Trace Amounts of Elements by Radioactivation Analysis, by H. M. Clark and R. T. Overman, 10 p., n.d., decl. 9/24/47.

Only those elements which can be activated by slow neutron capture are considered.

The following are described at length: the principles of the method, irradiation of samples, measurement of the activity, the absolute method, and the comparative method. A typical procedure is described for the determination of manganese in very pure aluminum hydroxide.

MDDC - 1330 Thirty-Two Photographs Illustrating Production of Radioactive Materials at Clinton Laboratories, Clinton Laboratories, 32 p. n.d., decl. 9/29/47.

The photographs illustrate methods used in shielding, handling, separating, storing, distilling, filtering, counting and shipping radioactive materials. The materials used in the illustrations include radioactive ruthenium, radioactive barium, radioactive iodine, methyl alcohol containing radioactive carbon, radioactive carbon labeled methanol, calcium nitrate containing carbon 14, radioactive phosphorous, sodium sulfide containing radioactive sulfur, and radioactive scandium.

The radiation instruments known as "cutie pies" are also illustrated.

MDDC - 1331 Walkie Poppy - A Portable Battery Operated Proportional Type Alpha Survey Counter, by R. A. Dandl, 13 p., June 30, 1945, decl. 9/26/47.

A battery operated, self-contained alpha pulse counting instrument sensitive to individual alpha particles was constructed for the audible detection of alpha contamination.

The instrument consists of a probe, operating as a proportional counter in air, an electronic high voltage supply delivering up to 3000 volts, a three stage amplifier, and a thyratron output circuit driving a set of headphones. The unit weighs nine pounds and consists of the circuit and batteries which are enclosed in an aluminum case measuring approximately 3" x 10" x 10"; the intermittent battery life of the unit (which has been field tested) varies from 8 to 12 operational hours.

No attempt was made to incorporate a rate meter in the circuit, as satisfactory surveying could be made by audible indication of alpha contamination.

Circuit diagrams and photographs of the instrument are included.

MDDC - 1332 The Basic Dry Chemistry of Neptunium, by S. Fried and N. R. Davidson, 53 p., n.d., decl. 7/18/47.

A description of the micro-techniques used in the preparation of neptunium compounds is given. Neptunium dioxide and sodium neptunyl acetate have been prepared and identified.

Neptunium trifluoride and tetrafluoride have been prepared by the reactions:

$$NpO_2 + 1/2H_2 + 3HF \rightarrow NpF_3 + 2H_2O$$

$$NpF_3 + 1/4O_2 + HF \rightarrow NpF_4 + 1/2H_2O$$

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The NpF_3 as observed with about 250 micrograms of material was dark purple. The NpF_4 was a light green material.

Neptunium tetrachloride was prepared by the reaction of CCl_4 vapor upon Np(IV) oxalate or NpO_2 at 500°C in a pyrex X-ray capillary. The $NpCl_4$ is formed as a yellow sublimate.

Hydrogen reduction of $NpCl_4$ at 450°C gave rise to $NpCl_3$.

The action of chlorine gas on $NpCl_4$ at elevated temperatures failed to yield any higher chlorides of neptunium.

Neptunium tetrabromide was prepared by the action of $AlBr_3$ on NpO_2, and the tribromide by the same reaction in the presence of excess aluminum.

Neptunium triiodide was prepared by the action of AlI_3 on NpO_2.

The reaction of an H_2S - CS_2 mixture on NpC_2 at 1000° for two hours gave rise to NpOS. Prolonged treatment under the same conditions yielded Np_2S_3.

Ignition of Np(IV) nitrate in 28 atmospheres of O_2 at 400°C gave rise to NpO_2, not a higher oxide. Under the same conditions U_3O_8 is converted to UO_3.

A tabular survey of the dry chemistry of U, Np, and Pu is given and the relationship between the stability of the different oxidation states in solution and in dry compounds is discussed.

In general, it is easier to obtain the higher oxidation states of the elements under discussion in solution than in dry compounds.

Among the pure compounds (solid or gaseous) the small positively charged ions of the various oxidation states must be stabilized by co-ordination to the anions of electronegative atoms. The small and difficultly polarizable anions, $O^=$ and F^- in general form compounds of higher oxidation numbers than do the more readily polarized anions, Cl^-, Br^-, $S^=$, and I^-.

Diagrams of apparatus are included.

MDDC - 1333 Fabrication of Gold-Beryllium Alloys, by H. Hirsch and J. M. Taub, 7 p., January 8, 1946, decl. 9/25/47. (LADC-264).

This report describes the development work and final method adopted for the production of a gold-beryllium mixture used in some experimental nuclear physics work. By this method, all alloying is avoided, which is desirable, since gold-beryllium alloys are extremely brittle, but at the same time a machinable, dense and homogeneous material is produced.

The approach to this problem was by means of powder metallurgy, and the development of this method is described.

The material used was minus-170 mesh gold powder and minus-400-mesh beryllium powder. The composition used was one atom of gold to two atoms of beryllium, which was equal to 8.45-weight-per cent or 49.05-volume-per cent of beryllium.

The procedure consisted of mixing the two powders and pouring the proper weight of powder into the pressing die. The complete assembly of die, powder and plunger was then brought up to temperature and held at temperature for at least one hour. The desired pressure was then applied and maintained for approximately five minutes, after which the compact was immediately ejected. In the case of pieces having a final height of 1/2 inch or less, two pieces could be pressed at one time by using a spacer in the die.

MDDC - 1334 **The Composition of Plutonium Peroxide, by H. H. Hopkins, Jr., 4 p., November 6, 1946, decl. 9/8/47. (CN-3688).**

Using an oxidation-reduction titration method the number of peroxide oxygen atoms precipitated with one atom of plutonium was determined. Assuming the plutonium to be entirely in the (IV) state, an average empirical formula of $PuO_{3.58}$ may be calculated from the data.

MDDC - 1335 **The Preparation of Aluminum Borohydride and Lithium Borohydride by Metathesis Reactions, by E. K. Hyde, 24 p., June 1946, decl. 9/19/47. (ANL-HDY-213).**

A satisfactory method of preparation was found in the metathesis between aluminum halides and alkali metal borohydrides as represented by the equation:

$$AlX_3 + 3MBH_4 \rightarrow Al(BH_4)_3 + 3MX.$$

X represents chlorine or bromine and M represents sodium or lithium. Reactions of this type produce in high yield a product free from volatile contaminants other than small amounts of diborane and small amounts of solid material, which are easily separated from the aluminum borohydride. There are no troublesome side reactions and the operations and equipment are comparatively simple.

The reaction of aluminum chloride and lithium borohydride was studied first. If the two solid materials are sealed off in an evacuated glass tube very little reaction occurs, but if the tube is continuously evacuated,the reaction proceeds smoothly at room temperature. To obtain a satisfactory yield it is, however, necessary to raise the temperature when the reaction begins to slow down.

The reaction of aluminum chloride and sodium borohydride is considerably more sluggish at room temperature than the reaction just described. When aluminum chloride and sodium borohydride are mixed in a glass tube and subjected to continuous evacuation, aluminum borohydride forms at only a very slow rate. By heating the mixture to a temperature of 60-80°C a yield of aluminum borohydride of about 30 to 40 per cent is obtained in 2 or 3 hours. If the temperature is raised to the neighborhood of 100°C, the total yield reaches nearly 60 per cent. Somewhere in this temperature range the reaction mixture cakes into hard, crusted lumps and the reaction virtually ceases.

At somewhat higher temperatures the mixture melts and the reaction proceeds satisfactorily.

Detailed procedures for the reactions, preparation of reagents, tabulated and plotted data and hazards involved are included.

MDDC - 1336 **Radiochemical Assay by Alpha and Fission Measurements, by A. H. Jaffey, 134 p., February 6, 1947, decl. 5/26/47. (CC-3771).**

Exceedingly small amounts of radioactive materials may be measured by the methods of radiochemical assay, amounts as small as 10^{-18} grams. In this chapter, methods for the radiochemical assay of alpha-emitters and of fissionable isotopes are discussed. The emphasis is on methods and instruments used and developed on the Plutonium Project, although work on other projects and in the published literature are discussed.

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Detailed discussion of the following subjects is presented: general properties of alpha particles and fission fragments; types of instruments used; instrumental factors affecting alpha and fission measurements; total alpha assay; alpha energy measurements; assay of fissionable isotopes by fission counting; sample preparation. The appendix includes discussion of: pulse formation in an ionization chamber; differentiation of pulses; noise level; and oscilloscope monitoring for pulse ionization counters.

Diagrams and a bibliography are included.

MDDC - 1337 Comparative Action of Cyclotron Neutrons and X-Rays. Part III. Statistical Analysis of Blood Data, by G. A. Sacher and N. Pearlman, 29 p., June 1946. (CH-3842).

The heterophil and lymphocyte counts of 67 rabbits exposed to fast neutrons, and those of 123 rabbits exposed to 200 kv X-rays, were analyzed.

Distributions of counts were normalized in conversion to logarithms. Responses of both blood systems to the two types of radiation were qualitatively similar.

The ratio of X-ray and neutron doses for equal effect on heterophil counts was determined by regressions between X-ray and neutron responses at like times after exposure, for various pairs of X-ray and neutron doses. The average of 29 estimates for X/n using this method, with its standard error, is 6.3 ± 0.10. The above method could not be used in the case of lymphocytes, but an alternative method gives 6.20 as the value for X/n.

The authors conclude that the heterophils and lymphocytes do not differ significantly in the X/n ratios, and that the numerical value of the ratio may be taken to be

$$X/n = 6.3 \pm 0.10.$$

MDDC - 1338 The Deposition of Pure Boron. I. A Static Method for the Preparation of Boron, by H. I. Schlesinger, G. W. Schaeffer, and G. D. Barbaras, 46 p., May 24, 1944, decl. 9/19/47. (CP-1588 (A-2228)).

The research described was undertaken to determine the feasibility of the deposition of boron films on metal surfaces by the thermal decomposition of diborane.

Detailed descriptions of procedure and preparative methods are presented. The subjects covered are as follows: The chemistry and thermodynamics of the thermal decomposition of diborane; methods of preparing boron fluoride diethyl etherate, sodium trimethoxy borohydride and diborane with descriptions of apparatus and procedure employed; methods of analysis of sodium trimethoxy borohydride, boron on glass, hydrogen by combustion, hydrogen by gas volume, boron and hydrogen from boron hydrides; the deposition of boron on glass; a method of stock for the analysis of volatile hydrides of boron by decomposition, the decomposition of boron on glass tubes and the minimum temperature of decomposition, the static method for the deposition of boron in glass tubes, applications to proportional counters; the static method for the deposition of boron on iron cylinders with a description of the apparatus and the procedure for the preparation of the cylinder, for the deposition of boron, heat treatment of the deposit and applications: ion chambers, counters. Preliminary results on deposition of boron by a flow method are also presented.

Diagrams of the apparatus used in the experiments are included. The methods described in the report have given excellent results but further research is needed to adapt them to a commercial or semi-commercial scale.

MDDC - 1339 **Deposition of Pure Boron. II. A Flow Method for the Deposition of Boron on Wires, by H. I. Schlesinger, G. W. Schaeffer, G. D. Barbaras, and T. Wartik, 22 p., August 17, 1944, decl. 9/25/47. (CP-2005).**

Very pure boron can be deposited on tantalum, tungsten, iron, constantan, chromel and alumel wires (but not on copper) by the thermal decomposition of diborane. (See MDDC-1338.) The present report describes the details of the method of deposition and some applications.

Diborane, when passed over a heated filament, decomposes according to the equation:

$$B_2H_6 = 2B + 3H_2$$

the boron being deposited on the wire. This method has several advantages over those which depend on the reduction of boron halides by hydrogen.

The only products of the reaction, aside from boron and hydrogen, are volatile higher hydrides of boron which, on continued heating or the use of slightly higher temperatures, are also converted into boron.

The reduction of boron halides, on the other hand, requires a much higher temperature, which frequently causes interaction of boron with the metallic filament; furthermore, these methods yield hydrogen halides as by-products, and these interact with the filament.

The low temperature at which boron may be deposited from diborane possibly has an advantage in addition to that already mentioned. The higher the temperature the greater the likelihood that boron will be deposited in crystalline form. There is reason to believe that it is the amorphous boron which has the high temperature coefficient of electrical resistance reported for this element. The possibility that the deposits obtained at low temperatures may exhibit a higher coefficient than those prepared by the older methods is now being investigated. Deposits prepared by this method have found application in neutron thermometers and high temperature coefficient resistors.

Diagrams and photographs are included.

See MDDC-1340 for a flow method for the deposition of boron on iron cylinders.

MDDC - 1340 **Deposition of Pure Boron. III. A Flow Method for the Deposition of Boron on Iron Cylinders, by H. I. Schlesinger, G. W. Schaeffer, G. D. Barbaras, and J. D. Farr, 16 p., November 14, 1944, decl. 9/18/47. (CP-2327).**

The previous reports of this series have described the deposition of thin boron films on iron cylinders by a "static method" (MDDC-1338) and on various kinds of wires by a "flow method" (MDDC-1339). The present report describes a rapid flow method developed particularly to deposit boron on iron cylinders 8" x 1 1/2" to be used for neutron counters. The method, however, is not limited to cylinders of this size or material.

The new technique has several advantages over the previously described "static" method. The time of deposition has been reduced from fifteen hours to two hours; the formation of non-volatile hydrides of boron, with its subsequent loss of boron, is completely eliminated; the accuracy of the determination of the amount of boron deposited is increased; the temperature of deposition can be reduced to 300°C; and the uniformity of the deposit is increased.

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In this method, diborane at a pressure between 1.5 and 2.0 mm of mercury is passed over the object to be coated. The object is heated by induction to a temperature from 300°C to 450°C, the optimum temperature being between 375°C and 425°C. Under the optimum conditions, about 40% of the diborane is converted to boron.

This report also describes experiments on the effect of the partial pressure of diborane and hydrogen, the temperature of deposition, the nature of the surface, and the rate of flow on the nature of the deposit.

Photographs and diagrams of apparatus are included.

MDDC - 1341 Uranium Borohydride, $U(BH_4)_4$, and Its Alkyl Derivations, by H. I. Schlesinger and H. C. Brown, 45 p., September 1, 1946, decl. 9/24/47.

When anhydrous uranium tetrafluoride (hereafter called uranous fluoride) is treated with aluminum borohydride a spontaneous, fairly strongly exothermic reaction occurs, in the course of which the light green finely divided uranous fluoride is replaced by lustrous green crystals which in larger aggregates appear almost black. After evaporation of the residual aluminum borohydride, these crystals may be sublimed in vacuo at room temperature to be recondensed in a vessel at lower temperature, and are thus separated from the other less volatile reaction products. Analysis and measurements of the vapor density of the new compound show it to be uranium (tetra) borohydride, $U(BH_4)_4$. On the basis of data described in the experimental part, the equation for the reaction may be written:

$$UF_4 + 2Al(BH_4)_3 \rightarrow U(BH_4)_4 + 2Al(BH_4)F_2$$

Treatment of the compound with trimethylboron leads to the formation of two additional new compounds to which the formulae, $U(BH_4)_3(BH_3CH_3)$, and $U(BH_3CH_3)_4$, respectively, have been assigned. The former, like the simple uranium borohydride, is obtained in the form of dark green crystals; the latter is a crystalline solid, almost colorless in thin layers, lavender to almost black in thicker crystals. Both of these compounds may be sublimed at room temperature, but there is sufficient difference in their volatilities to make possible almost complete separation of the two by fractional sublimation and condensation. Complete purification requires further treatment, which is based on the fact that the monomethyl derivative may be completely removed from the tetraderivative by treating the latter with excess of trimethylboron, whereas the tetramethyl derivative may be removed from the monomethyl derivative by careful treatment of the latter with diborane.

There are indications that compounds intermediate between the monomethyl and the tetramethyl derivative exist, but it has thus far proved impossible to obtain them in pure condition. Furthermore, other alkyl derivatives have been obtained by treatment of the simple borohydride with triethyl, tri-isopropyl and tri-t-butylboron, respectively. The products have, however, not yet been successfully purified since the higher alkyl diboranes, byproducts in the reaction, have volatilities of such magnitudes that they are difficult to separate from the uranium compounds. All of these derivatives are green, and no material similar to the lavender tetramethyl derivative was obtained.

Discussion at length of related compounds, properties, and reactions is presented.

MDDC - 1342 Studies of the Hemolytic Effect of Radiation, by S. Schwartz, et al., 65 p., July 10, 1946, decl. 9/23/47. (CH-3760).

Evidence is presented indicating that both acute and chronic radiation anemia are due in part to a hemolytic reaction, and not solely to an inhibition of erythropoietic activity as has been assumed by most investigators.

The hemolytic concept is based on the following evidence taken from a survey of the literature as well as from the authors' experimental studies. (1) The red cell count in human and animal subjects may fall at a rate that is faster than can be accounted for by assuming even 100 per cent inhibition of erythropoiesis. (2) The red cell count may decline at a time when the reticulocyte count is actually elevated. (3) Histological evidence of increased red cell destruction has been demonstrated repeatedly. (4) The bone marrow of humans that have anemia due to chronic radium poisoning is typically hyperplastic, not aplastic. (5) Increased bile pigment excretion has been shown to occur following administration of large doses of P^{32} or total body X-ray.

Excessive irradiation appears to destroy both mature and immature cells in increased amounts. More studies of human subjects are required to evaluate the importance of this hemolytic factor. Special attention in these studies should be given to bile pigment excretion and reticulocyte measurements.

A bibliography of 65 references is included.

MDDC - 1343 Acute Radiotoxicity of $(Ba\text{-}La)^{140}$ for Rats and Mice. Part III. Effects on Weight and Food Intake of Animals Treated with $(Ba\text{-}La)^{140}$, by R. H. Snyder, G. A. Sacher, and J. D. Teresi, 20 p., June 1946, decl. 9/15/47.(CH-3832).

In the $(Ba\text{-}La)^{140}$ experiments mice and rats were injected intraperitoneally with toxic doses of radiobarium. The weight curves indicate that there was definite retardation of growth in mice at 2.25 μc/g and in rats at 1.96 μc/g. The threshold for weight loss was, therefore, about half of the midlethal dose for each species.

There was a permanent, roughly constant deficit of growth after injection, which increased in magnitude with the size of the dose at a rate of 2.72 ± 0.25 per cent per μc/g.

Graphs and charts are included.

MDDC - 1344 Plutonium Project Record, Volume IX-B, Papers from Chapters 2, 3, and 4, edited by N. Sugarman, Argonne National Laboratory, 66 p., n.d., decl. 9/25/47.

This report is made up of a series of papers numbered MDDC-1344-A through MDDC-1344-G. These papers are individually abstracted below:

MDDC - 1344-A Low Absorber Counters, by N. Elliott, et al., 24 p., n.d., decl. 9/25/47.

The low absorber counter is an arrangement for the use of a Geiger-Müller tube for very weak radiations. Its chief use is for taking absorption curves on weak radiations, where the presence of the mica window on the usual thin-window tube sets a working lower limit to the absorber thickness.

The following counters are described: The Elliott low absorber counter; the Sullivan, Sleight, and Gladrow counter; the Raynor-Freedman modification. Drawings of the various parts of the Elliott low absorber counter are presented.

MDDC - 1344-B The Coseparation of Aqueous Ba Ion with Solid LaF_3, by H. Gest, N. E. Ballou, B. M. Abraham, and C. D. Coryell, 17 p., n.d., decl. 9/25/47.

The coseparation of Ba^{++} with LaF_3 has been studied with Ba^{140} as a radioactive indicator. The data obtained for the coseparation with internally formed LaF_3 in 0.5 M HNO_3 and 1 M HF can be represented by the empirical Freundlich equation: $\frac{x}{m} = 0.0135\ C^{0.4}$ (x = amount of Ba^{++} carried (mg/1); m = weight of LaF_3 (mg/1)) when m is of the order of 200 mg LaF_3/liter. With externally formed LaF_3 in 1 M HNO_3 and 0.5 M HF (m = 2000), the data can be described by a similar equation with different constants, viz., $\frac{x}{m} = 0.00175\ C^{0.64}$.

The coseparation with internally formed LaF_3 increases with increasing temperature and is partially reversible. None of the data could be represented satisfactorily by the Langmuir adsorption equation.

MDDC - 1344-C The Coseparation of Aqueous Fission Products with MnO_2, by H. Gest and L. E. Glendenin, 9 p., n.d., decl. 9/25/47.

The coseparation of mixed fission products with internally- and externally-formed MnO_2 precipitates was examined. In dilute HNO_3, Cb^{95}, Te^{129}, Zr^{95}, and possibly other isotopes are carried. In more concentrated HNO_3 (>10M), Cb, Te, and Mo are carried well.

The coseparation of Cb_{95} with externally formed, freshly precipitated, wet MnO_2 in 10 M HNO_3 (~0.6 gm MnO_2/liter at 70°C) is quantitative after thirty minutes of contact. Reagent grade MnO_2 (dry) is less effective.

In 1 M HNO_3 at 70°C, MnO_2 causes a partial separation of the Te^{129} isomeric pair, the 72m ground state being preferentially removed by the oxide.

MDDC - 1344-D A Double-Seat Glass Valve Useful in Remote-Control Chemical Systems, by H. A. Levy, 5 p., n.d., decl. 9/25/47.

This document consists of a diagram of the valve and a brief description.

The chief advantage of this design is its positive action, there being no trouble from sticking or from failure to seat. An inherent disadvantage is that, while the valve is closed, one side of the system is open to the outside through the upper sleeve; this is true also of the other side during the brief time the stem is in motion during activation.

MDDC - 1344-E A Magnetically Controlled Glass Valve, by L. G. Stang and H. A. Levy, 3 p., n.d., decl. 9/25/47.

A discussion is presented of the all-glass, greaseless valve which was briefly described in MDDC-1344-D. It consists essentially of the glass plunger seats containing a soft iron core against a ground surface in a glass jacket. The valve seats by gravity, the fluid flow through the device being stopped when the plunger drops. The sealing surfaces are spherically ground as this shape combines the advantages of large surface, non-critical sealing position and minimum tendency to stick.

The valve is opened when the plunger is raised as a result of activation of a solenoid surrounding the jacket. A rheostat should be placed in the circuit to permit gentle operation.

There is occasionally a tendency for the plunger to stick in the closed position or to fail to seat quite properly; this eventuality can often be overcome if an electric buzzer is attached to the outside of the jacket and activated at the time of the trouble.

The device may, if desired, be inverted, in which case it is normally open and is closed by activation of the solenoid.

This valve may be used in either liquid or gaseous systems. It does not give completely perfect seal but is sufficiently tight for many purposes.

The spherically shaped parts may be conveniently formed without use of a special template as follows. The plunger and jacket are first blown nearly to shape and are then partially ground together with an approximately spherical motion. The plunger is then softened in a flame, the surface tension of the glass tending to correct deviation from sphericity which may have been introduced in the grinding. Alternate grinding and softening is continued until a satisfactory form is achieved.

MDDC - 1344-F A Glass Reaction Vessel for Remote-Control Operations, by L. G. Stang and H. A. Levy, 3 p., n.d., decl. 9/25/47.

Further discussion is presented about the glass valve described in MDDC-1344-D and MDDC-1344-E.

The apparatus was proved satisfactory for carrying out precipitation reactions by remote control in volumes from about 100 ml to about 5 liters and with radioactivities as great as thousands of curies.

An essential feature of this vessel is that the bottom is formed by a sintered glass disc. The disc is made impervious to liquids by applying a positive pressure to that portion of the system, of which the vessel is a part, which communicates with the region beneath the disc. Excellent agitation of liquids can be achieved by applying sufficient pressure (about 5 psi with medium or 10 psi with fine porosity Corning discs) to cause a moderate stream of air to pass through the disc. Filtration is achieved by applying negative pressure.

Tests with a highly colored solution showed that if even a small flow of air through the disc is maintained, liquids can be held in the reactor indefinitely long. Should the agitation caused by the air stream be undesirable, the pressure can be so adjusted that no gas is passed; the disc is then still nearly impervious to liquids but will show appreciable seepage over an interval of several hours.

Medium porosity Corning discs were found to be most satisfactory with respect to filtering rate, and they would retain most precipitates. The fine porosity can be used, but longer filtering times and higher pressure for agitating the solution are thereby necessitated.

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The reaction vessel has a capacity of about 5 liters and was formed of two Erlenmeyer flasks whose bottoms were first removed. This shape was chosen because it permits easy and efficient washing of the walls. Semi-ball joints are placed on the top and bottom to permit quick removal of the vessel from an assembled system.

The inner tubes extending to the disc allow additional air to be bubbled through the solution for agitation and also permit the withdrawing of samples. The remaining tube permits the removal of part of a supernatant liquid after the precipitate has been allowed to settle.

The contents of the vessel may be heated by use of infrared lamps. It has been found possible also to heat the contents by passing steam instead of air through the disc; however, some difficulty may be caused by dilution of the solution with condensate and by contamination with oil usually present in steam lines. Steam may also condense in the pores of the disc, clogging it and necessitating use of higher pressures for cleaning.

MDDC - 1344-G A Remotely-Controlled Continuous Ether Extraction Apparatus, by G. H. Jenks and C. V. Cannon, 5 p., n.d., decl. 9/25/47.

A remotely-controlled glass apparatus for concentrating active material from uranyl nitrate solutions is described.

The general plan for preparing solutions of high specific activity was to bombard pure U_3O_8 in the pile, convert it to uranyl nitrate and ether extract and concentrate the aqueous solution.

The equipment devised for carrying out the concentration is described at length and a photograph is included.

MDDC - 1345 Vapor Pressure of Plutonium Trichloride, by B. Weinstock, 8 p., August 16, 1944, decl. 3/31/47. (LADC-171).

The vapor pressures of plutonium trichloride in the temperature range 659°C to 762°C are reported, as determined by Knudsen's method of molecular effusion. At 663° the pressure above the solid chloride is 4.6×10^{-5} mm Hg while at 741° it is 4.2×10^{-3} mm Hg. The pressure at 762°, at which the chloride is thought to be fused, is 7×10^{-3} mm Hg. The melting point is probably $760° \pm 5°C$. The vapor pressure above the solid chloride between 650° and 750°C can be represented by the equation:

$$\log_{10} P = - (2.1 \times 10^4/T) + 18.6$$

where P = pressure in mm Hg and T = absolute temperature.

A drawing of the apparatus used is included.

MDDC - 1346 **Absolute Beta Counting Using End-Window Geiger Muller Counter Tubes, by L. R. Zumwalt, 12 p., n.d., decl. 9/18/47.**

MDDC - 1156 is an abstract of this document.

MDDC - 1347 **A 4y Lanthanum Sub-Group Activity, by N. E. Ballou, J. Seiler, and L. Winsberg, 5 p., July 1947, decl. 10/14/47.**

A rare earth fission product of about 4-year half-life and emitting a 0.2 Mev β radiation has been found in U^{235} fission. On the basis of the chemistry used in the separation of this isotope, it is assigned to Nd or 61.

The rare earths were separated from the other fission products by a series of fluoride, oxalate and hydroxide precipitations. Cerium was removed from the other rare earths by precipitation of ceric iodate in 4N HNO_3. The Y group of rare earth was separated from the La group by several precipitations with K_2CO_3 solution. After 40-hour La and 13.8-day Pr had decayed only a previously unreported long-lived radioactive isotope remained. No change in the specific activity of this isotope was observed after several repetitions of the above series of chemical separations, indicating that it was not an impurity.

Attempts were made to determine the element assignment of this isotope by separation of the La fraction rare earths, i.e., La, Pr, Nd, Sm and Eu, which had been added to a fission product solution containing the long-lived activity. The La fraction was separated as given above, then Sm and Eu were removed by Na amalgam extraction, but the long-lived activity did not follow these elements. With the aid of a spectrophotometer the La, Pr, and Nd separations by K_2CO_3 precipitation were quantitatively followed, and the long lived activity followed Nd. On this basis it was assigned to Nd or 61. An aluminum absorption curve and a decay curve are given for the isotope.

MDDC - 1348 **Low-Energy Yield of $D(d,p)H^3$ and the Angular Distribution of the Emitted Protons, by E. Bretscher, A. P. French, and F. G. P. Seidl, 24 p., September 1, 1947, decl. 10/10/47. (LADC-439). (See also Physical Review, Vol. 73, p. 815-821, April 15, 1948.)**

The thick-target yield N(E) of the reaction, $D^2 + D^2 \rightarrow H^3 + H^1 + 4.0$ Mev, has been studied using a heavy-ice target, and the angular distribution of the protons observed. Experiments have been carried out from 15 to 105 kev incident deuteron energy. There is evidence that even for very small bombarding energies the angular distribution of protons in the c.g. system does not become isotropic. Computations of the cross sections $\sigma(E)$ from N(E) involve an estimate of the energy loss of deuterons in heavy ice. The variation of cross section $\sigma(E)$ with energy, E can only approximately be represented by a Gamow function, i.e.,

$$\sigma(E) \propto \frac{1}{E} e^{-c/\sqrt{E}}$$

The following diagrams are included: experimental arrangement; sectional view of vacuum tank and a circuit diagram of an automatic current integrator.

MDDC - 1349 **Slow Neutron Disintegration of Boron-10: Search for the Formation of Be(10) and Estimate of the Mean Life of Be(10), by E. Bretscher, 7 p., September 13, 1946, decl. 10/3/47. (LADC-338).**

Boron trioxide, irradiated in the Argonne heavy-water pile, was tested for Be(10) which may have been formed in a branching of the slow neutron disintegration of B(10). A comparison of the Be activity with that produced in Be metal by the same neutron flux leads to a branching equal to or lower than $1 \cdot 10^{-4}$.

MDDC - 1350 **Alpha Particle and Deuteron Tracks in Eastman NTA Photographic Plates, by R. L. Brock and E. Gardner, 9 p., n.d., decl. 10/3/47. (BP-121).**

Eastman NTA photographic plates have been bombarded with alpha particles and deuterons in the 184" Berkeley cyclotron, and photomicrographs of sections of tracks have been made. Alpha particles of all energies up to the full energy available from the cyclotron make recognizable tracks, but deuteron tracks can be followed only for energies below about 20 Mev.

Photomicrographs illustrating the following are included: alpha particle and deuteron tracks; enlarged sections of the tracks; grain densities of the tracks; sections of the track exposed to alpha particles at full energy available from the cyclotron.

MDDC - 1351 **Differential D(d,n)He^3 Cross Section for 10 Mev Deuterons, by B. R. Curtiss, J. L. Fowler, and L. Rosen, 6 p., August 13, 1947, decl. 10/13/47. (LADC-425).**

Deuterons from the Los Alamos cyclotron, focused at the center of a scattering chamber, were used to bombard a thin gas target and the number of He^3 particles observed which were emitted into a known solid angle in a given direction. Several gas targets were used so that, in the laboratory system, all angles from 20 to 42 degrees with the direction of the beam could be measured. The He^3 pulses were recorded by means of a proportional counter and amplifier and were analyzed with a ten-channel amplitude discriminator. The resulting plot of pulses per amplitude interval against amplitude gave a peak well resolved from background. The deuteron current was measured by means of a Faraday cage and current integrator. The value of the deuteron energy determined by magnetic deflection was 10.2 Mev, which value remained constant to about two per cent throughout the experiment. From the number of He^3 counts obtained in a given experiment and the integrated current the differential cross sections were calculated. These data indicate that in the center of mass system the differential cross section for the production of He^3 particles from this reaction is approximately independent of angle from 70 to 130 degrees. The total cross section obtained by extrapolation of the data is 0.04×10^{-24} cm^2.

MDDC - 1352 Resonance Reactions Involving Dirac-Type Incident Particles, by G. Goertzel, 11 p., July 11, 1947, decl. 10/8/47. (MonP-343).

An investigation has been made to determine whether the results of Wigner and Eisenbud can be extended to include the scattering of a particle which, in the region of no interaction, obeys a Dirac-type wave equation. It is found that no additional difficulties arise due to the use of Dirac particles and that the treatment of Wigner and Eisenbud can be carried through step by step with relatively minor changes.

In order to carry out this program, however, it was necessary to determine the appropriate relativistic boundary conditions to be satisfied by the external and internal wave functions at the boundary of the internal region. It is hoped that a comparison of the relativistic and non-relativistic boundary conditions will lead to a clearer understanding of the boundary conditions in the non-relativistic problem

MDDC - 1353 Fission of Elements from Pt to Bi by High Energy Neutrons, by E. L. Kelly and C. Wiegand, 18 p., August 14, 1947, decl. 10/3/47. (BP-112).

The neutron beam of the 184 inch cyclotron has been used to produce fission in elements from Pt to Bi. The fission yields relative to thorium for 90 Mev neutrons are bismuth 0.021, lead 0.0062, thallium 0.0036, mercury 0.0027, gold 0.0024, and platinum 0.0011. Yield curves for reduced neutron energies were determined. Significant differences in the fission yields of the abundant lead isotopes were found. The yields relative to thorium are Pb^{206} 0.0078, Pb^{207} 0.0113, and Pb^{208} 0.0032. With 90 Mev neutrons the fission fragment ionization relative to thorium was 0.8 for bismuth and ranged down to about 0.7 for gold.

A schematic diagram of the general arrangement and of the ionization chamber and associated apparatus are included.

MDDC - 1354 Relative Cross Sections of Reactions Induced by High Energy Neutrons in C, N, O, and F, by W. J. Knox, 6 p., n.d., decl. 10/3/47. (BP-116). (See also Physical Review, Vol. 72, p. 1254-1255, December 15, 1947.)

Various samples of graphite, Be_3N_2, BeO and LiF have been bombarded with high energy neutrons from the 184" cyclotron in order to determine the relative cross sections of certain nuclear reactions which occur. Beryllium and lithium compounds were used because these elements give no interfering activities in the range of half lives investigated. The neutrons used were produced by the action of 190 Mev deuterons on a 1/2" Be target. These neutrons have an energy distribution with a peak at about 90 Mev and width at half maximum of about 40 Mev. Bombardment times of from ½ to 30 minutes were used; the samples were placed on the wall of the cyclotron tank where the neutron beam emerges, and then spread in thin layers and measured on a GM counter.

The activities observed in these samples after bombardment were the well known isotopes C^{11} (20.5 min), N^{13} (9.93 min), O^{15} (2.1 min), F^{17} (70 sec), and F^{18} (112 min). Observed half lives agreed closely with reported values. (In the case of F^{17} the resolution of the curve was not good enough to check the half life accurately.) For comparison of cross sections of different reactions occurring in a single element a single sample was bombarded and its decay curve was resolved into the component activities. For comparison of cross sections of reactions occurring in different elements samples of two elements were bombarded simultaneously in the same beam and decay curves were taken on weighted samples. Each bombardment was repeated several times. In

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calculation of the relative cross sections corrections were made for self absorption of samples in counting and for length of bombardment. The relative activation cross sections found are given in the table below:

	Bombarded Element			
Product	C	N	O	F
C^{11}	1.00	0.38	0.36	*
N^{13}		0.28	0.14	*
O^{15}			1.1	*
F^{17}				*
F^{18}				1.2

*Observed but not quantitatively resolvable.

The reproducibility of the results is within a range of about 10% of the values given.

MDDC - 1355 Analysis of Dust and Fume Hazards in a Beryllium Plant, by S. Laskin, R. A. N. Turner, and H. E. Stokinger, 32 p., n.d., decl. 9/25/47. (II-188-7302).

A survey has been made of industrial health conditions of a beryllium plant in which many instances of beryllium poisoning have existed. The survey included an analysis of the dust and fume data taken under operating conditions at the plant. The results of this analysis have been correlated with the medical history of the plant.

The plant in question produces a technically pure beryllium metal and beryllium-copper alloy. The operations involve grinding beryl ore, sintering, conversion to the sulfate with sulfuric acid, furnacing to the oxide, treatment of the oxide by acid fluoride followed by a reduction of the beryllium fluoride to yield metallic beryllium. The beryllium-copper alloy is made by heating copper with beryllium oxide in the presence of carbon. The atmospheric contamination associated with these processes is in the form of dusts, fumes and mists. Selected areas were sampled, the selection being based on past medical history of hazard or on obvious contamination at the time of the survey. Sites selected were the ore-treatment area and the area around the beryllium fluoride and beryllium metal furnaces. Sampling equipment consisted of a Modified Cascade Impactor, Filter Paper Dust Sampler and a M.S.A. Midget Impinger. Samples were analyzed in most instances, both for beryllium and fluoride.

Of the three areas surveyed those of the beryllium fluoride and beryllium metal furnace showed the most hazardous concentrations of beryllium and fluoride. Most arresting was the disproportionately high fluoride concentration near the fluoride furnace. Concentrations 1000 fold that of beryllium were found. Such high concentration of fluoride may represent a hazard in itself. The concentration of beryllium 3 feet from the furnace opening during the pouring operation was approximately 0.065 mg/m^3. During the pouring operation of the beryllium metal furnace, beryllium concentrations varied from 1.4 to 4.7 mg/m^3 at approximately 3 feet from the furnace. Samples for fluoride in this site were of the order of 1.7 mg/m^3. Near the rotary kiln drier for beryllium ore treatment, beryllium dust concentration varied from 0.050 to 0.53 mg/m^3; fluoride concentrations in the air were of the same order

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of magnitude. A particle-size analysis of the air contamination samples by the means of the Cascade Impactor showed a mass-median particle size of 0.86 μ in the vicinity of the beryllium metal furnace, 2.46 μ next to the beryllium fluoride furnace, but sizes up to 10 μ in the area about the ore treatment room. The insoluble beryllium dusts were most efficiently sampled by either the Cascade Impactor or the Filter Paper Dust Sampler, but the Midget Impinger gave more satisfactory recoveries for soluble beryllium fumes.

Another problem investigated was that of beryl ores suspected of containing radioactive impurities. One of three suspected ores showed significant beta activity equivalent to 12.6% uranium, which on spectrochemical analysis later revealed 4% U, 0.4% Th, and 0.4% Pb. This degree of activity represents a definite thoron or radon hazard and suggests the possibility that uranium or other radioactive materials may act synergistically or as predisposing agents in beryllium poisoning.

The medical history of the plant over a 4-year period from 1943 to 1946 showed 136 cases of beryllium poisoning. Cases for the most part were confined to the preparation of sulfate, the fluoride, the metal, and the beryllium-copper alloy. The symptoms of exposure were confined chiefly to the skin and respiratory tract. The former was characterized by dermatitis and skin ulcer, and accounted for 50% of all cases. The dermatitis, affecting exposed areas of the skin, was often severe, being of the edematous, papulovesivular type. When the face was involved, there was invariably associated conjunctivitis. An element of sensitivity was believed demonstrated. It was not uncommon to find individuals showing both dermatitis and bronchitis, especially if permitted to continue work in the areas of the sulfating process and fluoride furnace. Chemical pneumonitis presented the severest type of beryllium poisoning and occurred among workers without respect to type of process. Several deaths from this cause were reported in 1943, typical symptoms were cough, substernal pain, shortness of breath, cyanosis, anorexia, weight loss and increasing fatigue. Vital capacity was reduced. There was a low grade fever. Recovery did not occur if work was continued. Examination of lung tissue sections showed a large number of plasma cells, diffuse pulmonary edema and hemorrhage. X-rays of the lungs were diagnostic.

The general plant history showed a shift in the number of cases through the years 1943-1946. During 1943 and 1944, the sulfate and beryllium-copper processes were particularly involved. Following improved conditions at this site, the production emphasis shifted to beryllium fluoride and beryllium metal where at present, the greatest proportion of cases now appear (1946). The number of cases ranged from 63.5 to 238.1 per million man-hours of exposure, whereas the acceptable number in well-established chemical industries is 4.

MDDC - 1356 Quantum Corrections to the Thermodynamic Properties of Liquids, With Application to Neon, by O. K. Rice, 16 p., n.d., decl. 10/8/47. (See also Journal of Chemical Physics, Vol. 16, p. 141-147, February 1948.)

The quantum correction has been expressed as a deviation η from RT ln Q_c, where Q_c is the classical partition function. Changes in volume, energy, specific heat, etc., caused by quantization can be expressed in terms of η and certain thermodynamic quantities. η itself is expressed in terms of thermodynamic quantities. The equations obtained give for solid neon the same results, within the limits of error as the usual treatment of a Debye solid with the aid of the Gruneisen equation. To apply the equation to liquid neon, various thermodynamic quantities have been obtained from known values for argon by use of the law of corresponding states. The difference in volume and specific heat of liquid neon from the values expected from the law of corresponding states have been computed and found to agree reasonably well with the observations. However the melting point, and the ΔE and ΔS of fusion are found experimentally to be much closer to the classical values than one would expect from the theory. No explanation of this discrepancy is apparent.

MDDC - 1357 Nuclear Reactions at High Energies, by R. Serber, 5 p., September 1, 1947, decl. 10/3/47. (BP-120). (See Physical Review, Vol. 72, p. 1114-1115, December 1, 1947.)

Consideration is given to the behavior of high energy particles on striking a nucleus. Because of their speed their interaction with a nucleus may be regarded as an interaction with only one of the nucleons but this nucleon cannot be regarded as free, as the momentum transfer to it at collision is not $\gg$ the characteristic momentum of particles in the nucleus. This leads to an increase, by a factor of 5/3, in the mean free path in the nucleus of the bombarding particle. From these considerations it is estimated that the mean free path of a 100 Mev bombarding nucleon $\simeq 4 \times 10^{-13}$ cm and its energy transfer to a struck nuclear particle $\simeq$ 25 Mev. The fate of the bombarding particle will depend on its collision parameter; if it passes through the periphery of the nucleus it will pass out with its energy reduced by $\sim$25 Mev. If it passes through the centre it may make several collisions and lose most of its energy. The results of these general considerations are then discussed in terms of excitation curves and total cross-sections for scattering and absorption.

MDDC - 1358 An Anomaly in the Study of Dielectric Constant, by J. Van Wazer and I. Halpern, 1 p., n.d., decl. 10/14/47.

The entire text of the report is reproduced below.

During a study of the dielectric constant of solid uranium tetrachloride of doubtful purity it was found that some samples showed frequency dispersion while others did not, with the high-frequency limiting dielectric constant of those samples exhibiting variation equal to the dielectric constant of the other samples. Since from X-ray measurements this salt does not appear to contain dipoles and there was no good indication of the existence of two solid phases under these conditions, a study was made of the thermal variation of the dielectric constant. Contrary to expectations, the dielectric constant increased with rising temperature. Attempts were made to explain these phenomena as the effect of (1) impurities in the solid (2) adsorbed HCl or other polar gases and (3) assuming that the uranium tetrachloride molecule is polar, an equilibrium between two solid structures in one of which there is no dipole rotation. The first two explanations do not agree in magnitude with chemical analysis, and the third is not in accord with X-ray structure studies. It was therefore concluded that the observed dispersion (ϵ = 8.0 at 200 c, ϵ = 4.5 at 100 kc for experiments on a sample at 110°C) and the temperatures variation (ϵ = 7.2 at 164°C, 4.5 at 110°C and 4.0 at 25°C at 100 kc) cannot readily be explained by existing theories of the behavior of solid dielectrics.

MDDC - 1359 Note on the High Temperature Hydrolysis of Plutonium Oxy-Chloride, by B. M. Abraham and N. R. Davidson, 6 p., decl. 10/13/47, (ANL-JJK-14B-34)

An attempt to measure the equilibrium constants for the reaction

$$PuO_2 + 1/2\ H_2 + HCl = PuOCl + H_2O$$

was made by analyzing the gas phase that results when PuO_2 is heated in the presence of H_2 and HCl. Complete equilibrium was evidently not attained, but the equilibrium constant for this reaction in the neighborhood of 550°C, is bracketed between 0.3 and 1.5 $atm^{-1/2}$. At 600°C, the equilibrium constant for the corresponding bromide reaction was bracketed between 0.3 and 0.46 $atm^{-1/2}$.

The apparatus used is illustrated.

MDDC - 1360 Thermal Neutron Fission Properties of Ra^{226}, by D. Ames and A. Ghiorso, 2 p., n.d., decl. 10/8/47. (ANL-JJK-14B-35)

The complete text of the document is reproduced below.

An upper limit for fissionability with thermal (i.e., cadmium absorbable) neutrons has been set for the 1600 yr. Ra^{226} (natural radium). An early measurement using 50 micrograms of Ra in the fission counting chamber had indicated a limit of .003 barns. More recent samples of repurified material show that this limit can be lowered to 10^{-4} barns.

The radium used in the early measurement was not purified but taken directly from a source of radium chloride. Spectrographic analysis showed 0.4% Ba, 0.2% Ca, 0.4% Mg and 0.2% Si.

The second samples were prepared from 20 milligrams of radium chloride which had been carried through 10 crystallization cycles. One cycle consists of precipitating the chloride from distilled (20%) hydrochloric acid in an ice bath, digesting for ca. one-half hour, centrifuging and redissolving in 100-200 microliters of Barnstead water. Spectrographic analysis showed less than tolerance limits of all elements ($\sim$0.02% Ba).

The sample plates were prepared by adding the chloride to the plate and spreading by dilution so that the solution almost covered the plate. A few small drops of ca. 1 M H_2SO_4 were added so that the sulfate was evenly spread on the plates.

Two samples, each weighing 100 micrograms, were carefully evaporated on platinum plates in the manner described. One had a fission counting rate of 43 f/m and the other a rate of 18 f/m over a background of 100 f/m at a sensitivity such that

$$\sigma_f \text{ barns} = 611 \times \frac{\text{f/m}}{\text{gm}}$$

$$\sigma = 611 \times \frac{43}{100 \times 10^6} = 2.6 \times 10^{-4} \text{ barns}$$

$$\sigma = 611 \times \frac{18}{100 \times 10^6} = 1.1 \times 10^{-4} \text{ barns}$$

Since the same fission rates would have been caused by 4 and 1 alpha c/m of Pu^{239}, respectively, the possibility of accidental contamination is very high. Taking the lowest value, the thermal fission cross-section of Ra^{226} is 1.1×10^{-4} barns.

MDDC - 1361 Colorimetric Determination of Microgram Quantities of Acid-Soluble Sulfide Sulfur, by E. C. Anderson, 10 p., n.d., decl. 10/3/47, (LADC-430).

Sulfide sulfur in the sample is converted to H_2S by treatment with HCl and is distilled into a solution of $ZnAc_2$. The distillate is treated with p-aminodimethylaniline and $FeCl_3$ which converts the H_2S to methylene blue. The latter is then determined spectrophotometrically.

The method is presumably applicable to any materials which dissolve in non-oxidizing acids with the release of their sulfide sulfur as H_2S.

The size of sample is determined by the sensitivity required. Since the limit of detection of the method is approximately 1 microgram, the limits of sensitivity are:

Sample size	Limit of sensitivity
10 mg.	100 ppm
100 mg.	10 ppm
1 gram	1 ppm

Literature references are included.

MDDC - 1362 Alkali Plutonium IV Fluorides, by Herbert H. Anderson, 5 p., n.d., decl. 10/8/47. (ANL-JJK-14B-32).

Quadrivalent plutonium precipitates as an alkali plutonium fluoride in the presence of alkali and fluoride ions. Isomorphous compounds have been prepared in the alkali plutonium pentafluoride series: $NaPuF_5$, $KPuF_5$ and $RbPuF_5$. The tiny crystals adsorb some water, most of which is lost upon drying in a vacuum. With cesium the light reddish-brown cesium diplutonium enneafluoride trihydrate, $CsPu_2F_9 \cdot 3H_2O$, precipitates; upon heating in a vacuum the water of hydration is lost with change of the color to light greenish-grey.

All formulas have been established by chemical analysis: Dr. W. H. Zachariasen has made X-ray measurements on samples finding isomorphism in the sodium, potassium and rubidium salts analogous to potassium uranium (IV) pentafluoride, KUF_5. A preparation containing supposedly only hydrogen, plutonium and fluoride (plus a little nitric acid) gave a reddish-brown precipitate found to be KPu_2F_9; conceivably the potassium was introduced through use of glass transfer equipment as well as through storage in pyrex glass.

The solubility of plutonium (IV) in the presence of lithium and ammonium ions has been measured also; the formula NH_4PuF_5 is quite probable, and the formula $LiPuF_5$ is likely. Potassium plutonium (IV) pentafluoride was the least soluble compound derived from plutonium tetrafluoride and was only about one fiftieth as soluble as the simple fluoride.

MDDC - 1363 Radiotoxicity of Injected Sr^{89} for Rats, Mice, and Rabbits, Part II. Metabolism and Organ Distribution, by D. Anthony, K. Lathrop, and R. Finkle, 27 p., August 25, 1947, decl. 10/9/47, (CH-3846).

Mice, rats, and rabbits excreted Sr^{89}-Sr^{90} very rapidly following intraperitoneal or intravenous administration. The greatest part of the excretion took place during the first three days, and by 10-15 days virtually no more of the retained strontium was excreted.

Average total excretion values were 54 per cent of the injected dose for the mouse, 40 per cent for the rat, and about 70 per cent for the rabbit.

Average total retention values were 45 per cent of the injected dose for the mouse, 59 per cent for the rat, and 21 per cent for the rabbit.

After three days almost all of the retained Sr^{89}-Sr^{90} was found in the skeleton. The concentration in bone was more than 100 times that in soft tissue.

There does not appear to be any significant variation in retention of Sr^{89} on a per gram basis between different types of bone.

The logarithm of the retention, the rate of excretion, and the blood concentration of radioactive strontium in each case was found to be a straight-line function of time.

MDDC - 1364 Radiotoxicity of Injected Sr^{89} for Rats, Mice, and Rabbits. Part III. Lethal Action and Clinical Changes, by D. Anthony, K. Lathrop, and R. Snyder, 17 p., June 1946, decl. 10/17/47. (CH-3845).

The LD_{50} in 30 days was found to be between 7 and 8 μc/g of Sr^{89} - Sr^{90} when administered intraperitoneally to mice; for rats it was slightly less than 5 μc/g; and for rabbits it was also slightly less than 5 μc/g.

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The food intake and gain in weight of rats and mice given doses of 2 μc/g or more, but showing no apparent symptoms of radiation sickness, were less than those of the control animals.

MDDC - 1365 The Halides of Neptunium, by L. Brewer, L. Bromley, P. Gilles, and N. Lofgren, 8 p., October 11, 1945, decl. 10/8/47. (CN-3306).

Heats of formation for neptunium halides are given, which together with values of $\frac{\Delta F - \Delta H_{298}}{T}$ found elsewhere can be used to calculate free energies of formation. The high temperature chemistry and methods of preparation of neptunium halides are given.

MDDC - 1366 The Effect of K^+ and La^{+3} on the Solubility of Plutonium (IV) Fluoride, by M. Cefola and C. Smith, 3 p., n.d., decl. 10/8/47. (ANL-JJK-14B-42).

Evidence has been obtained for the existence of double fluorides of plutonium(IV) with lanthanum and potassium. When various small amounts of $La(NO_3)_3$ were added to solutions of Pu(IV) in 1 M HF-0.4 M HNO_3, precipitates formed which contained two moles of La per mole of Pu. Since the Pu in similar precipitates has been shown to be Pu(IV), a compound $La_2PuF_{10}{\cdot}xH_2O$, is certainly definitely established. The dried fluoride precipitate from K-Pu(IV) solutions has been identified as $KPuF_5$ by an X-ray diffraction analysis.

MDDC - 1367 Hydrogen Reduction of Pu(IV) to Pu(III) in Aqueous Solution, by R. E. Connick and W. H. McVey, 9 p., n.d., decl. 10/13/47.

Hydrogen gas in the presence of a platinized platinum catalyst was used to reduce a dilute hydrochloric acid solution of Pu(IV) to Pu(III). It was possible to produce solutions containing less than 1% Pu(IV) if precautions were taken to minimize the amount of oxygen coming in contact with the platinum foil subsequent to reduction. If these precautions were not observed, small amounts of hydrogen peroxide were produced in the solution. Hydrogen reduction affords a very convenient method of preparing pure Pu(III) solutions free of oxidizing or reducing agents.

MDDC - 1368 Experiments on the Electrodeposition of Uranium from Aqueous Solutions, by O. A. Cook, 8 p., August 27, 1945, decl. 10/10/47.

All of the experiments were made with a rotating platinum anode and a fixed copper cathode. In every cell bubbles of oxygen were evolved at the anode.

The following topics are considered at length: analytical techniques for uranium; temperature effect; effect of hydrogen ion concentration; effect of uranyl concentrations.

At 0.15 amp/dm^2 between 2 to 4 volts, the optimum conditions for electrolysis of uranyl solutions are temperatures above 80°C, and a pH between 5 and 7. However, pH 6 and 7 are more advantageous than pH 5 as the uranium oxide deposit adheres to the cathode better. At pH5 the uranium oxide flakes off very readily during the electrolysis. As an empirical rule for the successful deposition in acetate solutions, it is apparently necessary to avoid ratios of uranium to acetate salts greater than 0.05.

MDDC - 1369 The Electrolysis of Uranium Halides, by B. J. Fontana, E. D. Eastman, and R. A. Webster, 13 p., n.d., decl. 10/9/47.

The electrolysis of tetra- and tri-halides of uranium in fused salt systems at temperatures from 700° - 900°C has been investigated. Serious losses were found to be caused by reaction with atmospheric oxygen, refractories and electrode materials. The tetrahalides are particularly active as oxidizing agents, even apart from the electrolytic process. The electrolytic behavior of trivalent uranium salts indicates the existence at high temperatures of an oxidation state of uranium lower than U (III).

MDDC - 1370 Preliminary Studies on the Physical Metallurgy of Beryllium, by P. Gordon, 39 p., August 1945, decl. 10/9/47. (CT-3315).

Preliminary studies of the physical metallurgy of Be have been carried out. Precision X-ray measurements showed the lattice parameters for Be to be a_0 = 2.2808 A and c_0 = 3.5755 A. Addition of alloying elements had little effect on the parameters. Identification of inclusions resulting from various added foreign elements has been made by metallographic examination. Electrical resistivity measurements on unalloyed Be after extrusion and heat-treatment failed to reveal any systematic relationship between the resistivity and the amounts of various impurities. Extruded Be rods and tubes had a marked degree of preferred orientation: The grains were randomly oriented about the rod, or tube, axis but with the basal (002) planes tending to become parallel to the axis. Annealing at about 1000°C appreciably reduced the degree of preferred orientation. At about 725° to 750°C recrystallization took place after annealing a few hours, but at 700°C recrystallization was not complete even after 100 hours of annealing. As an extruded metal it had tensile strengths of 40,000 to 50,000 psi but only a few tenths of 1 per cent elongation; annealing between 725° and 800°C produced tensile strengths of 50,000 psi with as much as 3 per cent elongation in the extrusion direction. Small amounts of various alloying elements had little effect on the tensile properties. Comparison of the ductility of an extruded unannealed tube in the extrusion direction with that across the extrusion direction indicated that the per cent elongation parallel to the tube axis was about 3 times that perpendicular to the axis.

Diagrams and photographs of microstructures are included.

MDDC - 1371 Studies of the Preparation and Properties of Plutonium Iodide and Plutonium Oxy-Iodide, by F. Hagemann, et al., 9 p., n.d., decl. 10/13/47. (ANL-JJK-14B-33).

Bright green plutonium triiodide was prepared on the 50 and 500 microgram scale by treatment of plutonium metal with hydrogen iodide gas at 400°C. The reaction of 50 to 500 microgram quantities of plutonium metal with excess iodine in the liquid or vapor phase, in platinum or glass apparatus, gave rise to plutonium oxyiodide, PuOI, rather than the triiodide.

The oxyiodide was obtained when plutonium dioxide was treated with anhydrous hydrogen iodide at 750°C or when a plutonium(III) iodide solution was evaporated to dryness in the presence of excess ammonium iodide in a stream of hydrogen iodide at reduced pressure. Attempts to make plutonium triiodide by treatment of the dioxide with aluminum iodide in the liquid or vapor phase or by treatment of a plutonium oxide, carbon mixture with hydrogen iodide at elevated temperatures were not successful.

A bibliography of 19 references is appended.

MDDC - 1372 Comparative Action of Cyclotron Fast Neutrons and X-Rays. II. Hematological Effects Produced in the Rabbit by Fast Neutrons, by L. O. Jacobson and E. K. Marks, 32 p., June 1946, decl. 10/8/47. (CH-3839).

Swift snuffle-free rabbits, weighing approximately 2000 grams each, were exposed to cyclotron fast neutrons provided by the reaction of 8 Mev deuterons on a beryllium probe. The fast neutron particles reaching the animals had traversed from 2 to 4 inches of lead to eliminate the gamma component. Hematological studies were conducted on the animals after exposure and at frequent intervals thereafter through 37 days. The range of dosages employed was from 9 to 178 fast neutron units.

A severe anemia (frequently 50 per cent or more reduction in hemoglobin and erythrocyte values) followed doses in the range of the LD_{50} (128-145n) or above. This anemia reached a maximum within the first two weeks after exposure. Reticulocytes were drastically reduced with similar doses reaching values of 0.1 per cent or less by 3 days. Recovery from the anemia and return of reticulocyte values to normal in surviving animals followed the pattern observed after LD_{50} doses of X irradiation.

After doses of 80-89 fast neutron units and 100-108 units a maximum reduction of approximately 75 per cent in the platelets (per mm^3) occurred with a return to normal values by 15 and 23 days, respectively, in the two exposure levels.

An initial rise in heterophils followed exposure to doses of fast neutrons of 9 through 128 units. A reduction that reached a minimum level between 3 and 5 days followed the initial rise after doses ranging from 26 to 128 units. No significant reduction occurred after an exposure to 9 fast neutron units. Recovery to normal limits in all groups except in the group that received 128 fast neutrons had occurred by 16 days. The animals in this latter group expired prior to the 16th day.

After the administration of doses ranging from 9 fast neutrons to 128 fast neutrons, lymphocyte values fell by 3 hours after exposure, and a continuing reduction reached a minimum by 2 or 3 days. "Recovery" followed within 5 days after an exposure to 9 fast neutron units. With doses above this (26 to 128), "recovery" was not complete by 37 days.

An "abortive rise" in both heterophils and lymphocytes occurred between the 4th and 11th day after exposure. This rise in heterophil values was observed after doses of 89 fast neutron units and above and a secondary fall preceded the eventual return to normal values. With a dose of 55 fast neutron units and above, a similar secondary fall preceded the return of the lymphocyte values toward the normal range.

Morphological changes in the cellular constituents of the peripheral blood after exposure are identical with those occurring after comparable doses of X-radiation.

A comparison of the relative effectiveness of cyclotron fast neutrons and X-radiation made on the basis of the degree of heterophil or lymphocyte depression at arbitrarily chosen times after exposure of animals to thses radiations gave variable results. The X/n ratios thus derived varied from 6 to 22. The X/n ratios derived from a statistical study of the lymphocyte-heterophil response in rabbits exposed to fast neutrons and X-ray are for the lymphocytes 6.4 and for the heterophils 6.3 ± 0.1.

MDDC - 1373 Analytical Chemistry of the Manhattan Project. Chapter XIX. Silicon, by K. Jensen and C. J. Rodden, 15 p., n.d., decl. 2/27/47.

Determinations for silicon in uranium ores and uranium metals are presented.

The determination of macro amounts of silicon as silica followed usual procedures given in standard texts.

The conventional molybdosilicic acid method was used for the colorimetric determination of silica. The carrier-distillation method was used extensively in the spectrographic analysis of uranium and its compounds.

Detailed procedures are given for the following: determination of SiO_2 in uranium metal and oxide; determination of SiO_2 in UF_4; the analysis of soluble salts of uranium: in the presence of phosphate, in the absence of phosphate (range 0.5 to 14 γ), in the absence of phosphate (range 0.02 to 2.5 γ).

A bibliography of 21 references is appended.

MDDC - 1374 Preparation, Purification, and Properties of Anhydrous Uranium Chlorides, by O. Johnson, T. Butler, and A. S. Newton, 43 p., n.d., decl. 10/9/47.

Methods of preparing anhydrous uranium trichloride, uranium tetrachloride, uranium hexachloride, and uranyl chloride are described which use uranium metal as the starting material. Uranium trichloride has been prepared by the action of hydrogen chloride on uranium hydride or powdered uranium metal at 250°C. The tetrachloride has been made by reaction of chlorine with the trichloride and by direct reaction of chlorine (diluted by an inert gas) on uranium hydride. The hexachloride has been prepared only by disproportionation of chlorides having a chlorine to uranium ratio of around 5.5. Uranyl chloride was found to be most satisfactorily made by the reaction of uranium tetrachloride and oxygen at 300°C.

The densities of these compounds and of the pentachloride have been measured by the liquid displacement method and also determined from X-ray diffraction data. The densities in g/cm^3 obtained by liquid displacement method are 5.35 for uranium trichloride, 4.88 for the tetrachloride, 3.81 for the pentachloride, 1.56 for the hexachloride, and 5.38 for uranyl chloride, all at 25°C. The densities based on X-ray measurements are 5.51 for the trichloride, 4.87 for the tetrachloride, and 5.43 for uranyl chloride.

Vapor pressure measurements have been made for uranium tetrachloride and uranium hexachloride by the transpiration method. The vapor pressure of the tetrachloride is 0.9 mm at 450°C and 100 mm at 675°C; that of the hexachloride is 0.06 mm at 75.5°C and 1.75 mm at 138°C. Uranium tetrachloride melts at 590°C and boils at 802°C under 740 mm pressure. There is X-ray and thermal evidence for a crystal transformation in uranium tetrachloride at 545°C.

The reaction between chlorine and uranium tetrachloride or uranium trichloride has been shown to produce higher uranium chlorides in which the chlorine to uranium ratio varies with the reaction temperature.

Corrosion studies have been made on nickel and stainless steel and some refractory materials at 600°C.

A bibliography of 39 references is included.

MDDC - 1375 The Effect of Uranium Exposure on Urine Catalase Excretion, by E. J. Katz, L. G. Holt, and S. Schwartz, 12 p., June 15, 1946, decl. 10/4/47. (CH-3594).

No significant difference has been found in the urine catalase activity of control and uranium-exposed personnel. A prompt marked increase in urinary catalase activity lasting one to two weeks is found in rabbits injected with a kidney-damaging dose of uranium nitrate. Control rabbits have more catalase activity in the urine than do any humans studied, with the exception of those with known kidney pathology.

None of the human group studied have been exposed to an acute overwhelming dose of uranium which is in any way comparable to the dose administered to the rabbits studied.

A bibliography of five references is included.

MDDC - 1376 The Quantitative Micro Determination of Plutonium, by C. W. Koch, 6 p., n.d., decl. 10/8/47. (ANL-JJK-14B-4).

A quantitative method for the determination of plutonium using ceric sulfate has been developed. A Jones reductor is used to reduce all the plutonium present to Pu(III) and the Pu(III) is then titrated to Pu(IV) with ceric sulfate. The ferrous complex of o-phenanthroline is the indicator used. The reproducibility on 2.5 mg samples of plutonium as plutonium sulfate is $\pm$ 0.25%.

MDDC - 1377 Analysis of Hydroxide Precipitates from Plutonium (IV) Solutions, by K. A. Kraus, 17 p. n.d., decl. 10/9/47. (ANL-JJK-14B-11).

Precipitates obtained from Pu(IV) nitrate and Pu(IV) sulfate solutions on addition of base have been analyzed. It was found that some basic salt formation often occurs on precipitation. The composition of the thoroughly washed materials was almost that of a hydroxide, being, however, probably better represented by the approximate formula $Pu(OH)_{3.85}X_{0.15}$. A method based on pH determinations is described for the detection and analysis of basic salts.

MDDC - 1378 Oxidation of Plutonium(IV) to Plutonium(VI) by Nitric Acid, by K. A. Kraus, 6 p., n.d., decl. 10/8/47.

The rate of oxidation of Pu(IV) to Pu(VI) by HNO_3 was studied with the HNO_3 concentration varying from 0.5 to 14 M. It was found that oxidation occurs only at elevated temperature, proceeds rapidly at low HNO_3 concentration, and is inhibited at high concentration. Oxidation by dilute HNO_3 appears to be a practical method of preparing Pu(VI) solutions from Pu(IV) solutions.

It was noted that at high HNO_3 concentration the color of Pu(IV) is brilliant green, that the absorption spectrum differs markedly from that in dilute HNO_3, and that complexing of Pu(IV) occurs. This complexing may be responsible for the retardation of the rate of oxidation of Pu(IV) by more concentrated HNO_3.

MDDC - 1379 **Analytical Chemistry of the Manhattan Project. Chapter XXIII. Sulfur, Selenium, and Tellurium, by F. E. McKenna and D. H. Templeton, 40 p., n.d., decl. 10/8/47.**

The following methods for the determination of sulfur are discussed at length: gravimetric, titrimetric, colorimetric, and nephelometric. The titrimetric methods were found satisfactory for relatively large amounts of sulfide. For trace determinations, the methylene blue colorimetric method is satisfactory; the lead sulfide stain method is more sensitive, but less accurate. The nephelometric barium sulfate or the colorimetric estimation with benzidine can also be used.

Diagrams of apparatus are included.

Various methods for separating selenium from uranium and other interfering elements are given. Distillation with hydrobromic acid was found to be the most effective.

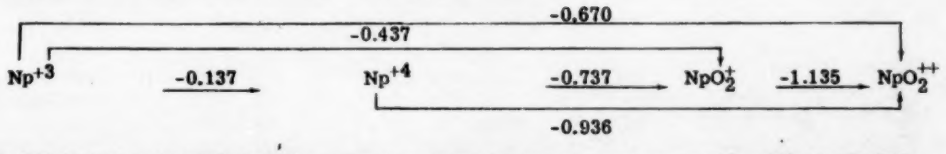
For the determination of tellurium a colorimetric method whereby the transmitting of colloidal tellurium is measured was found to be the most satisfacotry after separating the tellurium with sodium hypophosphite.

MDDC - 1380 **Chemistry of Element 93. IV. Preparation and Properties of Neptunium(III), by L. B. Magnusson, T. J. LaChapelle, and J. C. Hindman, 13 p., n.d., decl. 10/8/47. (ANL-WMM-141).**

The formal potential of the Np(III)-NP(IV) couple was found to be -0.137 volts in 1.0 M HCl. The Np(III) ion is intermediate in stability between U(III) and Pu(III) in aqueous solution. The couple behaved reversibly over a seventy-fold change of ratio of Np(IV) to Np(III). Details of the absorption spectrum of the aqueous Np(III) ion are given.

MDDC - 1381 **Chemistry of Element 93. V. Formal Oxidation Potentials of Neptunium Couples, by L. B. Magnusson, J. C. Hindman, and T. J. LaChapelle, 19 p., n.d., decl. 10/8/47. (ANL-WMM-115).**

The formal oxidation potentials for the various neptunium couples have been measured in 1.0 M HCl. These may be represented schematically as follows:



The Np(III)-Np(IV) and Np(V)-Np(VI) couples have been found to behave reversibly while the Np(IV)-Np(V) couple is irreversible. In the latter case measurements of the potential in a system in equilibrium with Fe(II) and Fe(III) have been used to obtain the value of the couple. The Np(V)-Np(VI) couple has been found to be independent of hydrogen ion concentration in the range 0.1 M to 1.0 M hydrogen ion at a constant 1.0 M nitrate concentration. Partially on the basis of this result, it has been concluded that the probable formula of the Np(V) ion is NpO_2^+.

Because of perferential complexing of Np(IV) and Np(VI) by sulfate, the potentials of the couples in

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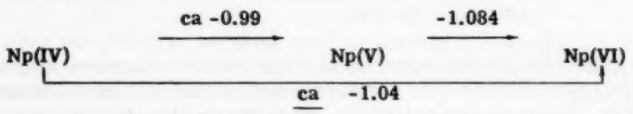
1.0 M H_2SO_4 are altered. The scheme in this acid is



A bibliography of seventeen references is added.

MDDC - 1382 Four Photographs, Nos. 1156, 1157, 1159, 1260, of Health Physics Instruments, 5 p., n.d., decl. 10/9/47. (See also Chemical and Engineering News, Vol. 25, p. 3794-3798, December 22, 1947.)

These pictures were used as slides with lectures and for educational talks on Health Physics.

1156 - These are all portable Geiger counters (beta-gamma scanning instruments)—the Simpson low voltage pocket type audio detector, and the Walkie-Squawkie.

1157 - Landsverk-Wollan electrometer. This is a portable electroscope for monitoring the intensity of alpha, beta and gamma radiations.

1159 - Pocket electroscopes which can be read by the wearer at any time during a process or during the day by holding it up to the light and observing the position of the fiber on a scale, thereby learning the total amount of radiation exposure to that time.

1260 - Zeus, a beta-gamma intensity measuring device which may be also used to read the intensity of alpha radiation in the range from 5,000 to 60,000 dis/min.

Cutie-Pie. This is a portable beta-gamma intensity meter.

MDDC - 1383 35 Millimeter Camera (9 Drawings), by S. H. Neddermeyer, 10 p., n.d., decl. 10/3/47. (LADC-432).

This is an electrically operated 35 mm camera, which is a modification of a similar camera borrowed from California Institute of Technology. It is used by the Los Alamos Laboratory for taking cloud chamber pictures. This camera changes film and resets itself. It uses about 10 feet of film per day and the magazine holds 100 feet of film. It is equipped with a Kodak F-2 lens and takes a picture in about 1/200 second.

MDDC - 1384 Note on Back-Scattering of Pu^{239} Alpha Particles from Platinum Sample Plates, by J. H. Parsons, et al., 1 p., n.d., decl. 10/8/47. (ANL-JJK-14B-26).

The complete text of the document is reproduced below.

An attempt has been made to evaluate the back-scattering of plutonium alpha particles (3.7 cm range in air) from platinum sample plates by first counting the sample in a vacuum low geometry chamber of calculated geometry, and then counting the same sample in the Simpson proportional counter and correcting for coincidence in both cases. No self-absorption corrections were made as the samples

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were evaporated from tetraethylene glycol and were extremely thin.

The counting yield of the Simpson proportional counter was found to be the same as the standard chambers so that it was assumed that the back-scattering factor obtained for the Simpson Proportional Counter would also apply to the standard chamber.

The following table gives the data up to the present time:

Sample	Counting Rate in Vacuum Chamber No. 1 Factor: 3654	Counting Rate in Vacuum Chamber No. 2 Factor: 3872	Disintegrations per min in sample	Counts per minute in Simpson Proportional Counter	Counting Yield of Simpson Proportional Counter (%)
1	75.3 $\pm$ 0.4 (NTE)*		275,200	142,900	51.9
2		73.4 $\pm$ 0.4	277,600	143,000	51.5
3	74.9 $\pm$ 0.4		273,500	142,700	52.1

* Nine-tenths error (due to statistics of counting).

MDDC - 1385 Composition of Plutonium(IV) 8-Hydroxyquinolate, by R. L. Patton, 2 p., n.d., decl. 10/3/47. (ANL-JJK-14B-62).

Analysis by specific alpha activity of plutonium(IV) 8-hydroxyquinolate showed that it contains four moles of organic radical per mole of plutonium. Therefore, the coordination number of Pu(IV) in such compounds is eight.

Since compounds of 8-hydroxyquinoline with metallic cations have two linkages from each organic radical to the central atom, analysis of the plutonium(IV) compound reveals the coordination number of Pu(IV). A very small amount of the solid can be analyzed by means of a determination of its specific alpha activity. All of the mass is assumed to be either plutonium or the 8-hydroxyquinolate radical. Analysis of plutonium(IV) acetylacetonate has previously indicated a coordination number of eight for Pu(IV).

The method of preparing plutonium(IV) 8-hydroxyquinolate is described.

MDDC - 1386 Volumetric Determination of Microgram Quantities of Acid-Soluble Sulfide Sulfur, by L. P. Pepkowitz, 5 p., n.d., decl. 10/3/47. (LADC-431).

The sulfur is distilled as hydrogen sulfide from acid solution and absorbed in an excess of calcium hypochlorite. The sulfide is oxidized to sulfate and the excess calcium hypochlorite is determined iodometrically. Stoichiometric relationships, however, are no borne out experimentally. Quantitative results are obtained by determining the titer values of the reagents against known quantities of sulfide.

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The method is presumably applicable to all materials which are soluble in 2 N HCl and give up their sulfide sulfur as H_2S under such circumstances. The principal application is to metals.

The sample size is determined by the sensitivity required. The absolute limit of sensitivity is about 1 γ of S. The procedure may also be used for determining milligram quantities of sulfur if 0.1 N solutions are employed.

Drawings of the pyrex distillation apparatus are included.

MDDC - 1387 Radiotoxicity of Injected Sr^{89} for Rats, Mice, and Rabbits. Part IV. The Hematological Effects of Enterally and Parenterally Administered Strontium^{89} in Mammals, by E. L. Simmons and L. O. Jacobson, 95 p. August 1946, decl. 10/8/47. (CH-3797).

Hematological studies of the peripheral blood of rabbits, rats, and mice, after the intraperitoneal or stomach tube administration of Sr^{89} in doses from 0.015 to 14.5 μc/g for varying periods up to 108 weeks, are reported.

With the techniques employed in this experiment, a reduction in the heterophil values was the most sensitive indicator of acute and subacute effects. Moderate but significant reduction in heterophil values followed the intraperitoneal injection of 0.068 μc/g in ABC male mice; no effect was apparent after the administration of 0.015 μc/g by the same route in two strains (ABC males and CF_1 females). Progressively more significant and sustained reduction in heterophil and lymphocyte values followed higher doses. No anemia occurred in mice with doses of 0.034 μc/g or lower, but moderate and sustained anemias were apparent with doses of approximately 2.0 μc/g.

The minimal exerting a mean detectable reduction in heterophil values in rats was between 0.22 and 0.25 μc/g. Doses above this level produced a progressively more severe heterophil depression and lymphopenia. Stomach tube administration of the isotope was studied in rats for comparison with the intraperitoneal route. Approximately twice the intraperitoneal dose is required by stomach tube to produce a comparable effect on the hematological constituents of the peripheral blood.

An intraperitoneal dose of 1.0 μc/g produced a reduction of heterophil values of significance in the rabbit. Following an intraperitoneal dose of 3.0 μc/g, a significant reduction in hemoglobin and erythrocyte values occurred with a rapid recovery. A sustained heterophil and lymphocyte reduction of significance was also apparent after this dose.

Sr^{89} produced morphological changes in the cells of the peripheral blooc in these three species comparable to those observed following the administration of plutonium, radium, or total body X irradiation.

Anemias that developed in these three species, after Sr^{89} intoxication, were characteristically normocytic, normochromic, but occasionally hypochromic, and macrocytic anemias were seen. Although drastic depletion of hemopoiesis in the bone marrow follows Sr^{89} intoxication, anemias failed to develop in mice with doses of 0.34 μc/g, due apparently to the rapid development of extramedullary erythropoiesis in the spleen and liver particularly. A dose of 2.0 μc/g, however, produced a moderately severe anemia in this species.

14 references.

MDDC - 1388 The Excretion, Retention, Distribution, and Clinical Effects of Strontium^{89} in the Dog. Part 1. Report of Experimental Work, by Marguerite N. Swift and C. Ladd Prosser, 63 p., n.d., decl. 10/9/47. (CH-3843).

In adult dog, the 30 day LD_{50} for intramuscularly injected Sr^{89} (with some Sr^{90} contamination) was approximetely 1.0 μc/g injected dose or 0.5 μc/g retained dose at 10 days, corrected for excretion and decay. Death within 30 days appears more closely correlated with the injected dose than with retained dose, indicating that the greater portion of the lethal effect was exerted within the first day or two, or possibly within the first few hours, after injection.

Excretion of Sr^{89} was rapid during the first three days, falling off thereafter. The rate of excretion showed no correlation with the administered dose within the range used (0.1-3.13 μc/g). The proportionate excretion in urine and feces varied with variation in amount of excreta but averaged about 50 per cent higher in the feces. This difference was maintained. Both excretion patterns decreased exponentially with an average slope of 1.8 on a log-log plot. Blood concentrations declined similarly.

At 3 days, the average retention (based on loss by excretion and decay) was 61.4 per cent for 11 adults, 67.2 per cent for 3 young adults, and 84.6 per cent for 4 puppies (aged 4-6 months). At 10 days, these same groups had retained 45.6 per cent, 59.7 per cent, and 79.9 per cent, respectively. A few days later (puppies averaged 4.8, young adults, 6.7, older dogs, 12.2), the rate of actual excretion of Sr^{89} became less than the loss by decay so that the decrease in radioactivity in the body from that point on was largely a function of the half-life of the material (55 days).

Survival time shows some, but not close, correlation with dosage. Five adult animals receiving 1.50-3.13 μc/g lived an average of 10.7 days, whereas four given 0.30-1.0 μc/g averaged 20.4 days. Only one animal, a puppy, died subacutely (at 83 days), and this occurred after a dose well above the minimum which killed both the puppies and adults acutely.

Sr^{89} content of total carcass plus the amount excreted, corrected for decay, gave 82.2 per cent and 90.6 per cent recovery in two adult dogs at 9 and 12 days. In 9 adults, femur content averaged 1.32 per cent and rib content, 0.26 per cent on the injected dose. In 2 puppies, the femur content averaged 3.30 per cent and the rib, 0.40 per cent. Teeth showed a slightly lower specific activity than bone. Soft tissues contained much smaller amounts of material, although trachea and larynx (analyzed in one dog) contained more than was expected on the basis of other soft tissues.

The nonsurvivors remained in apparent good health until about a week before death, at which time fever (a rise of 1-2°C), lethargy, anorexia, loss in weight (as much as 23 per cent decrease at death), cutaneous hemorrhages to a greater or lesser degree, and frequently edema of face, neck, or extremities, and ulcerated areas on the body or in the mouth developed.

The symptoms progressed rapidly, and the dogs died in a state of extreme prostration.

The leucocyte count declined rapidly, beginning a day or two after injection. Leucocytes were virtually absent from the circulation as early as several days before death. The red cell counts decreased more gradually than the leucocyte counts, death often intervening before an appreciable change had occurred. Five dogs which had been given high doses (average survival time 10.7 days) showed an average decrease of 23.4 per cent in red cell count; whereas four nonsurvivors which had been given lower doses (average survival time 20.4 days) showed an average decrease of 41.5 per cent. Reticulocytes disappeared from the blood almost immediately after injection. Other concomitant symptoms were a marked increase in clotting time and sedimentation rate, and an increase in total serum protein with a decline in the albumin and increase in the globulin fractions.

Survivors showed some or all of these signs and symptoms to a greater or lesser degree depending somewhat on the dose administered. The drop in the white count averaged 62.2 per cent for the dogs at the lowest dose level (0.1 μc/g), and reached about 90 per cent in the survivors at the highest dose

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(1.0-1.9 μc/g). In all cases, the depression was followed by a slow recovery which was often not complete by as long as 5 or 6 months. At all dose levels, lower red counts were observed in survivors than in nonsurvivors since the decrease in this component of the blood does not reach a maximum until 3 to 6 weeks after injection. An average maximum decrease of 46.0 per cent was observed in the four survivors at the highest dose level. Recovery was not complete for several months. Sedimentation rate and clotting time returned to normal much earlier than the red cell count.

Autopsy of 12 animals revealed extensive hemorrhages ranging in size from petechiae to large diffuse hemorrhages several centimeters in size. There were found in 5 or more of the dogs, in the following order of decreasing frequency; heart, colon, small intestine, lymph nodes, stomach, kidney, intercostal muscle, pleurae, diaphragm, caecum, and bladder. Several of the animals also showed hemorrhages in skin, lung, mesentery, gonads, adrenals, tongue, rectum, and pancreas. Ulcers were frequent in all parts of the small intestine. Definite edematous thickening of the whole gut was observed in five animals. Some congestion and edema of the lung was noted in three animals.

MDDC - 1389 Analytical Chemistry of the Manhattan Project. Chapter XXIV. Phosphorus, Arsenic, Antimony, and Bismuth, by D. H. Templeton and L. G. Bassett, 34 p., n.d., decl. 4/30/47.

The following analytical procedures are presented for phosphorus: methods of solution; methods of determination; gravimetric analysis; determination as magnesium pyrophosphate, determination as uranyl pyrophosphate; volumetric analysis: phosphomolybdate method, determination of pyrophosphate, procedure for copper pyrophosphate, procedure for total pyrophosphate; colorimetric analysis: hydrazine reduction method, stannous chloride reduction method, procedure (no extraction), procedure (butyl alcohol extraction).

Interest in the determination of arsenic was chiefly concerned with trace impurities for which high sensitivity but not high accuracy are required. The following procedures are presented for arsenic: methods of solution; methods of separation; gravimetric analysis: determination as As_2S_3; volumetric analysis: determination with iodine; colorimetric analysis: Gutzeit method.

The chief interest in the determination of antimony was for traces in uranium and uranium bearing material. The following analytical procedures are presented: methods of solution; methods of separation; methods of determination; colorimetric analysis: pyridine iodide method.

The following analytical procedures are presented for bismuth: methods of solution; methods of separation; methods of determination; gravimetric analysis: determination as bismuth phosphate; volumetric analysis: oxine iodide method; colorimetric analysis: dithizone method, tetraphenylarsonium chloride method, potassium iodide method.

MDDC - 1390 Dimerization and Adsorption at the Dropping Mercury Electrode, by G. H. Tishkoff, 7 p., n.d., decl. 9/15/47. (II-188-7349).

This document is a theoretical discussion of the polarograph. A general equation is derived on the assumption of dimerization and adsorption to interpret abnormal polarographic waves.

MDDC - 1391 Some Reactions of Uranium Metal, by J. C. Warf, 15 p., n.d., decl. 10/9/47.

A summary of certain reactions of uranium metal is presented. Uranium is a strong reducing agent and reacts with a wide variety of substances. Descriptions are given of its reactions with a number of materials, including air, oxygen, hydrogen, hydrogen chloride, chlorine, nitrogen, water, hydrofluoric acid, hydrochloric acid, nitric acid, sulfuric acid, phosphoric acid, perchloric acid, organic acids, silver and copper salts, metals, alkaline peroxide solutions, bromine, carbon, silica, uranium tetrafluoride, and uranium dioxide.

35 references.

MDDC - 1392 Thermal Neutron Cross Sections for Elements and Isotopes, by K. Way, N. Dismuke, L. Noderer, 14 p., April 28, 1947, decl. 9/24/47. (MonP-289).

This report consists of two tables.

In Table I the compilers give their judgment of the "best values" of the absorption and scattering cross sections of the elements based on all the experimental data available at present. Where only total cross section measurements have been made, these are given for absorption plus scattering and are marked A + S. Estimates are given of the reliability of the values.

In Table II the values given are the "best" experimental results for the absorption, scattering, and total cross sections based on measurements of each particular cross section. For this reason this table may show discrepancies between the sums of the values for A and S and the corresponding total cross section T. This table also includes masses and spins from the Project Handbook, abundances and half lives from a revised Seaborg Table.

MDDC - 1393 Preparation and Properties of Plutonium Silicides, by E. F. Westrum, Jr., 4 p., n.d., decl. 10/8/47. (ANL-JJK-14B-17).

Attempted vapor phase reductions of PuF_3 with $CaSi_2$ at 1550°C gave rise to $PuSi_2$ even when the $CaSi_2$ reductant was present in stoichiometric proportion for the production of metal. An attempt to carry out the reaction.

$5PuO_2 + 2CaSi_2 + 2Na_2CO_3 \rightarrow 5\ Pu + 2CaSiO_3 + 2CO_2 + 2Na_2SiO_3$, resulted in the formation of Na metal rather than Pu Metal. Ignition of $PuSi_2$ in air at 700°C produced PuO_2.

MDDC - 1394 The Crystal Structure of $PuSi_2$, by W. H. Zachariasen, 4 p., n.d., decl. 10/8/47. (ANL-JJK-14B-10).

$PuSi_2$ is tetragonal. The unit cell contains four molecules and has dimensions $a_1 = 3.97 \pm 0.01$A and $a_3 = 13.55 \pm 0.05$A. The calculated density is $\rho = 9.12$.

The space group is 14/amd and the atomic positions are: (000) (1/2 1/2 1/2) +

4Pu in (000) (0 1/2 1/4)
8Si in (00u) (00u) (0, 1/2, 1/4+u) (0, 1/2, 1/4-u).

The parameter value is u = 0.417.

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Each plutonium atom is bonded to twelve silicon atoms and each silicon atom to six plutonium atoms and to three silcon atoms. The interatomic distances are Pu-Si = 3.01A and Si-Si = 2.27A.

The compounds $ThSi_2$, USi_2, and $CeSi_2$ are isomorphous.

MDDC - 1395 The Crystal Structure of Sodium Plutonyl- and Sodium Neptunyl Acetates, by W. H. Zachariasen, 4 p., n.d., decl. 10/8/47. (ANL-JJK-14B-8).

$Na(PuO_2)(C_2H_3O_2)_3$ and $Na(NpO_2)(C_2H_3O_2)_3$ are isomorphous with the corresponding uranyl compound. The unit cube containing four molecules has an edge a = 10.659 $\pm$ 0.002A for the neptunium compound and a = 10.643 $\pm$ 0.002A for the plutonium compound. The calculated desities are ρ = 2.556 for the neptunium and ρ = 2.578 for the plutonium compound.

The space group is $T2_13$. Only the positions of the heavy metal atoms are known.

MDDC - 1396 X-Ray Diffraction Studies of Fluorides of Plutonium and Neptunium; Chemical Identity and Crystal Structure, by W. H. Zachariasen. 16 p., n.d., decl. 10/8/47. (ANL-JJK-14B-13).

The determination of the chemical identity and of the crystal structure of a number of plutonium and neptunium fluorides is discussed. The list of fluorides include: PuF_3, NpF_3, PuOF, PuF_4, NpF_4, $PuF_4.2.5\ H_2O$, NpF_6, KPu_2F_9, KNp_2F_9, $NaPuF_5$, $KPuF_5$, $RbPuF_5$.

Lattice dimensions and partial or complete structures are given for all of the compounds.

40 references.

MDDC - 1397 Photographs of Health Physics Instruments Used at Clinton Laboratories, by K. Z. Morgan, 14 p., n.d., decl. 6/17/47.

This document consists of 14 photographs of Health Physics instruments which are used at Clinton Laboratories, (Oak Ridge National Laboratories).

MDDC - 1398 Further Evidence for a γ - p Process in Be^9, by R. L. Conklin and W. E. Ogle, 6 p., n.d., decl. 10/22/47.

A previous paper has reported observation of a γ - p process in Be^9. In that work the 12 Mev beta-particles from the decay of Li^8 were observed above the background of 3.7 Mev betas from He^6, also formed during the irradiation by the process $Be^9(n,\alpha)He^6$. Li^8 decays into Be^{8*}, which promptly breaks up into two alpha particles. The observation of these alphas should furnish further proof of the presence of Li^8. Such an experiment has been performed, and alpha-particles have been observed from beryllium after irradiation by 20 Mev X rays. The decay half-life is within experimental error of the 0.88 second half-life of Li^8.

MDDC - 1399 Total Cross Sections of Nuclei for 90 Mev Neutrons, by L. J. Cook, E. M. McMillan, D. C. Sewell, and J. M. Peterson, 4 p., September 10, 1947, decl. 10/22/47. (BP-122). (See also Physical Review, Vol. 72, p. 1264-1265, December 15, 1947.)

Good geometry neutron attenuation measurements were made using a 184-inch cyclotron as a neutron source and carbon discs as detectors. The source was a 1/2'' Be target inside the cyclotron traversed by 190 Mev deuterons giving neutrons of 90 Mev mean energy with spread of $\pm$ 15 Mev.

Cross section measurements were made of Li, Be, C, Mg, Al, Cu, Zn, Sn, Pb, and Cl in the elemental form. The H cross section was measured by taking the difference between carbon and paraffin blocks having approximately the same attenuation; the D-H difference was found by a comparison of heavy and light water contained in thin-wall aluminum cells. O, N, and Cl cross sections were computed from attenuations in water, melamine, and carbon tetrachloride.

When the cross sections determined were expressed in terms of a collision radius R, where $\sigma = 2\pi R^2$, and plotted against $A^{1/3}$ it was seen that the values from Li to U lay on a nearly smooth curve, and were all below a line [$R = (1.7 + 1.22A^{1/3}) \times 10^{-13}$ cm] determined by Sherr for 25 Mev neutrons. The difference became less for the heavier nuclei; the values tending to approach Sherr's line. An interpretation was that the lighter nuclei are partially transparent, and approach opacity within increasing A.

An empirical formula fitting the cross section data from Li to U was found to be: $R = (0.5 + 1.37A^{1/3})[1 - \exp(-0.49A^{1/2})] \times 10^{-3}$ cm. From D to O the cross sections are nearly proportional to A.

MDDC - 1400 Multiple Nuclear Isomerism, by E. der Mateosian, M. Goldhaber, C. O. Muehlhause, and M. McKeown, 4 p., July 27, 1947, decl. 10/29/47. (ANL-HDY-274). (See also Physical Review, Vol. 72, p. 1271-1272, December 15, 1947.)

In the course of an investigation of the activity induced in Sb by slow neutrons, three previously unobserved short periods were noticed. An analysis of the decay curves obtained under various conditions of bombardment yielded the following half life periods: 1.3 min, 3.5 min, and 21 min. Though a short bombardment brought out these activities quite well relative to the long lived known Sb^{122} (2.8 d) and Sb^{124} (60 d) activities, the saturation intensities were only of the order of a few tenths of one per cent of those of the long lived activities. The new activities were observed with a number of samples of Sb of different origin. The activities were observed with epicadmium neutrons as well as thermal neutrons and it was shown that all three activities induced by epicadmium neutrons were strongly "self-absorbed" by Sb, which made it unlikely that they were due to impurities. Using a sample of Sb enriched in Sb^{123}, it was found that the 1.3 and 21 min. periods were due to isomers of Sb^{124} (60 d) and the 3.5 min. period was due to an isomer of Sb^{122} (2.8 d). Characteristic K α radiation of Sb was found to be associated with the 3.5 min period, but not with the 1.3 and 21 min periods. The 3.5 and 21 min periods both showed intense internal conversion electrons with half value thicknesses in Al of 1.7 mg/cm^2 and 0.2 mg/cm^2, respectively. It appears therefore that the energy of the isomeric transition of Sb^{124} (21 min) is unusually low and smaller than the K work function of Sb (31 Kev). If it is assumed that the 110 Kev electrons are K electrons and the 14 Kev electrons L electrons, the energy of the isomeric transition of Sb^{122} (3.5 min) is approximately 140 Kev, and that of Sb^{124} (21 min) is approximately 20 Kev.

The 1.3 min. isomer decayed with the emission of beta rays of 3.2 $\pm$ 0.2 Mev, maximum energy going presumably to the ground state of Te^{124}. The partial isotopic cross section for the formation of these isomer was $\sim 0.03 \times 10^{-24}$ cm^2. Gamma rays and other β branches were also observed and are being studied further.

MDDC - 1401 The Beta and Gamma Spectra of Ga^{72}, by S. K. Haynes, 5 p., n.d. decl. 10/22/47. (See also Physical Review Vol. 73 p. 187-188. January 15, 1948).

For related paper see MDDC - 1686.

The experimental curves obtained in an investigation of the beta- and gamma-ray spectra of Ga^{72} with a thin lens spectrometer are presented and discussed. Evidence is given for the existence of beta-particle groups with maximum energies of 3.15 Mev, (9.5 to 20%) 2.5 Mev, (8 to 18.5%) 0.955 Mev, (32%) and 0.64 Mev, (40%). The photoelectron spectrum indicates gamma rays of the following energies: 2.51 Mev (26%), 2.21 Mev (31.5%), 1.87 Mev (7.5%), 1.59 Mev (4.5%), 1.05 Mev (4.5%), 0.84 Mev (100%), 0.63 Mev (18.5%), and possibly a weak gamma ray at 1.25 Mev (2%). A conversion line appears at 0.68 Mev in the beta-ray spectrum but no corresponding line can be identified with certainty in the photoelectron spectrum. The conversion coefficient is probably between ten and fifty per cent indicating an isomeric state of considerable duration. A partial decay scheme of Ga^{72} is presented.

MDDC - 1402 On the Capture of Electrons by Ions, by Julian K. Knipp, 4 p., n.d. decl. 10/20/47.

The Oppenheimer-Brinkman-Kramers theory of the capture of electrons by alpha particles in their passage through matter is reformulated in terms of a momentum representation of the electrons. A Thomas-Fermi treatment of the atoms with which the particles collide gives capture cross sections in air in good agreement, except for extreme values of the particle velocity, with cross sections calculated from a Hartree model. Capture into excited electronic states becomes of primary importance for heavy ions carrying a core of electrons. Total cross sections for such ions are estimated assuming hydrogen-like representations for the electron in the captured state and the Thomas-Fermi model for the atom from which capture takes place.

MDDC - 1403 The Half Life of Carbon 14, by L. D. Norris and M. G. Inghram, 27 p., n.d. decl. 10/22/47. (See also Physical Review 73, p. 350-360, February 15, 1948.)

By determining the specific activities of two mass spectroscopically analyzed samples of barium carbonate containing C^{14}, the half-life of the C^{14} was found to be 5100 ± 200 years. In order to determine the relative abundance of C^{12}, C^{13} and C^{14}, the $C^{14}O_2$ was roasted from the barium carbonate and introduced into the mass spectrometer. Weighed portions of the barium carbonate were subsequently counted in a low absorption beta counter. Details of the analysis, weighing and counting are given.

Drawings of the low absorption counter are included.

18 references.

MDDC - 1404 **Radioactivity Distribution in the Tissues of Mice Bearing Melanosarcoma After Administration of dl-Radiotyrosine Labeled with Carbon 14, by J. C. Reid and H. B. Jones. 19 p., September 24, 1947, decl. 10/29/48. (BC-83).**

The synthesis of dl-tyrosine-β-C^{14} is described.

The distribution of radioactivity following intravenous administration of radio dl-tyrosine to mice bearing melanosarcoma has been investigated.

After 72 hours, about 30% of the administered dose appears in the breath, about 40% in the urine and feces, with 30% remaining in the body.

Radioactivity is found in every tissue of the body. The adrenals, thyroids, intestines, kidneys, liver, plasma, spleen and tumor show the highest specific activities. Erythrocytes are lowest, with bone next.

The gross half time for turnover of radioactivity in the body for the period between 12 and 72 hours after administration is 60 hours.

14 references.

MDDC - 1405 **I. Some new β-Diketones Containing the Trifluoromethyl Group. II. Keto-Enol Relationships in β-Diketones Containing the Tri-fluoromethyl Group, by J. C. Reid and M. Calvin. 24 p., August 13, 1947, decl. 10/24/47. (BC-75).**

By the Claisen condensation of ethyl trifluoracetate on a series of methyl alkyl ketones, propionyltrifluoracetone, 1-acetyl-1-trifluoracetylethane, 1-propionyl-1-trifluoracetylethane, isovaleroyltrifluoracetone, heptoyltrifluoracetone, benzoyltrifluoracetone, p-phenylbenzoyltrifluoracetone, p-fluorobenzoyltrifluoracetone, 2-naphthoyltrifluoracetone, 2-furoyltrifluoracetone, and 2-thenoyltrifluoracetone, all previously unreported, have been synthesized along with copper chelates and oximes prepared from them as characterizing derivatives.

Kinetic and thermodynamic constants for the process Keto$\rightleftharpoons$Enol have been measured for acetyltrifluoracetone, isovaleroyltrifluoracetone, benzoyltrifluoracetone and thenoyltrifluoracetone.

The effect of the trifluoromethyl group on the keto-enol equilibrium is understandable in terms of the strong negative inductive effect of the trifluoromethyl group.

MDDC - 1406 **Notes on the Ehrenfest Problem, by H. A. F. Siegert, 3 p., n.d., decl. 10/22/47. (LADC-438).**

The Ehrenfest problem which is an example of a Markoff chain is solved by means of generating functions.

MDDC - 1407 Thallous and Sodium Plutonium (III) Sulfates, by H. H. Anderson, 6 p. July 1946, decl. 10/20/47. (ANL-JJK-14B-67).

Thallous ion, plutonium (III) and sulfate give thallous plutonium (III) disulfate tetrahydrate, $TlPu(SO_4)_2 \cdot 4H_2O$, comparable to the cesium, rubidium, and ammonium double salts. With a high ratio of thallium to plutonium a tetrasulfate complex is indicated; due to the limited solubility of $TlHSO_4$ and a slight solubility of the double salt it was possible to reach only 95 per cent pure $Tl_5Pu(SO_4)_4$. Sodium, plutonium (III) and sulfate form only sodium plutonium (III) disulfate tetrahydrate $NaPu(SO_4)_2 \cdot 4H_2O$, a sky blue crystalline solid of rather limited solubility. Solubilities have been measured.

MDDC - 1408 Heavy Duty Crystal Spectrometer, Argonne National Laboratory, 61 p., August 1947, decl. 10/20/47.

A series of engineering drawings for a heavy duty crystal spectrometer. The unit is a single crystal monochromator which is used much the same as an X-ray spectrometer. A collimated beam of neutrons is obtained by introducing two thick cadmium slits, some distance apart, in the neutron beam from the thermal column of the pile. This collimated beam falls upon the (100) planes of a large single crystal(calcite or lithiumfluoride) and the diffracted beam is detected by a BF_3 proportional counter.

MDDC - 1409 Description of Purification and Filling Technique for BF_3 Ionization Chambers, by C. P. Baker and J. A. Bistline, 5 p., n.d., decl. 10/22/47. (LADC-417).

Either boron trifluoride gas as commercially available or boron trifluoride etherate commercially available may be used. In starting with gas, the first step is to form the etherate which is done simply by mixing; the dimethyl or diethyl ether is suitable. The etherate is then mixed with reasonably dry calcium fluoride. Apparently, a calcium fluoborate is formed and the ether is regenerated. The dimethyl comes off as a gas; the diethyl can be evaporated off with gentle heating. The calcium fluoborate can be stored indefinitely if kept dry. Normal open storage is not adequate as the glass container in which it has been kept will show etching indicating decomposition.

Before filling an ionization chamber, the calcium fluoborate must be thoroughly outgassed. A glass vacuum system with mercury pump was used and outgassed at 100 degrees C in a vacuum of between 10^{-3} and 10^{-5}. This generally requires about 24 hours. To prepare the system for filling a chamber, the calcium fluoborate complex is sealed to the system, and liquid air placed on the removable trap. The complex is then outgassed at 100 degrees C and the stopcock closed. The trap is removed, cleaned, and replaced and the chamber checked for leaks and pumped down to 10^{-4} or 10^{-5}. To fill the chamber the stopcock to the pumps is closed and a dry ice pack placed over the removable trap. The BF_3 is produced by heating the complex between 280 and 330 degrees C with a small electric furnace. When the desired pressure is reached, the heat is removed and the stopcock closed. To insure a good vacuum, the BF_3 is frozen out in the freeze-out tube with liquid air and the system opened to the pumps until a satisfactory vacuum is reached. The liquid air is removed and the chamber filled and sealed off.

A large portion of the remaining BF_3 can then be absorbed back into the cooled CaF_2 and the rest frozen out in the freeze-out tube and removed to another system for recombination with ether.

The ionization chambers are normally filled to two atmospheres. Most of the negative ions are collected as electrons and the number-bias curve is good. A potential of between 2 and 3 kilovolts is

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necessary and the insulators must be thoroughly clean and dry, both inside and out.

A chamber filled to 20 cm BF_3 and 50 cm argon needs no special precautions on gas purity.

No recovery methods for BF_3 was attempted, but it is anticipated that one could recover a large fraction by freezing the BF_3 with liquid air, forming the etherate and then the calcium fluoborate.

Drawings of the vacuum system and the ionization chamber used are appended.

MDDC - 1410 Stars in Photographic Emulsions. Part 1. Experimental, by E. Gardner, and Vincent Peterson. 1 p., October 2, 1947, decl. 10/29/47, (BP-129). (See also Physical Review Vol. 73 p. 533, March 1, 1948.)

This document is an abstract and the entire contents are reproduced below. For complete paper see MDDC - 1594.

Photographic plates have been bombarded in the 184" Berkeley cyclotron for the purpose of studying stars initiated by deuterons and alpha particles. The number of prongs (i.e., the number of charged particle tracks making up the star) have been tabulated for 1200 stars initiated by deuterons and 100 stars initiated by alpha particles. Protons of energy more than about 10 Mev do not make recognizable tracks in the emulsions which are being used, so the results will not include prongs due to high energy protons. For stars initiated by deuterons more 3-prong stars are found than any other kind. This is true for all incident deuteron energies from 40 Mev to 190 Mev. Preliminary results indicate that for stars initiated by alpha particles the average number of prongs is slightly higher. For deuteron-initiated stars there are about three times as many prongs in the direction of the beam as in the backward direction.

The cross section for formation of stars by alpha particles is being measured by counting sections of tracks made by alpha particles and the stars originating on these tracks.

MDDC - 1411 Stars in Photographic Emulsions. Part II. Theoretical, by W. Horning. 1 p., October 2, 1947, decl. 10/29/47. (BP-130). (See also Physical Review Vol. 73 p. 533-534, March 1, 1948.)

This document is an abstract and the complete text is reproduced below.

The number of stars observed as a function of the number of prongs has been computed on the basis of nuclear model described by R. Serber. The method of the calculation is to compute first the distribution of excitation energies of a nucleus, for a given energy of the bombarding particle. The statistical model is then used to predict what particles will be evaporated from the nucleus at each excitation. The average number of prongs per star thus obtained varies somewhat with energy, from 3.0 for 40 Mev deuterons to 3.9 for 190 Mev deuterons. This agrees roughly with the observed average prong number of 3.0 for all incident energies used. Since the ratio of neutron to charged particle evaporation is greater for heavier elements, the lighter elements in the photographic emulsion contribute strongly to the visible stars. The recoil of these lighter nuclei accounts roughly for the observed angular distribution of star prongs, assuming that evaporation is spherically symmetric with respect to the parent nucleus.

MDDC - 1412 The Reduction of Uranium Hexafluoride to Uranium Tetrafluoride, by I. B. Johns, et al., 17 p., August 18, 1945, decl. 10/17/47.

The reduction of UF_6 with hydrogen, hydrogen bromide, hydrogen chloride, ammonia, ethylene, and sulfur dioxide has been investigated. Hydrogen bromide at 80°C and hydrogen chloride at 250°C give the best reductions. Hydrogen does not reduce UF_6 readily, but the product is a complex salt, probably NH_4UF_5. Ethylene reductions give UF_4 mixed with carbon. The recommended method is the use of HCl at 250°C in a nickel apparatus. An apparatus suitable for the reduction is described.

10 references.

MDDC - 1413 Tracer Scale Evaluation of The Formal Potential of the Plutonium (IV)-Plutonium (VI) Couple in 1 M Nitric Acid, by E. F. Orlemann and B. B. Brody. 3 p., July 1946, decl. 10/20/47. (ANL-JJK-14B-23).

A technique is described for the determination of the formal potential of the couple,

$$Pu^{+4} + 2H_2O = PuO_2^{++} + 4H^+ + 2e-,$$

at a plutonium concentration of approximately 10^{-3} M. The experimental results yield a calculated value of -1.08 v. as the formal potential of this couple in 1 M HNO_3.

4 references.

MDDC - 1414 Laboratory Handling of Radioactive Materials, by P. C. Tompkins. 26 p. n.d., decl. 10/22/47.

The objective is to conduct laboratory work in such a manner that no part of a person's body accumulates more than 0.1 rem in any 24 hour period, and so that no physiologically dangerous quantities can accumulate in the body.

Good monitoring instruments are important. A G. M. Probe for table top work, and Cutie Pie for external radiation are recommended.

The complete elimination of mouth pipetting is necessary and the substitution of a device such as a Caulfield pipettor or a syringe type control should be made. One should also be careful to keep drops of solution away from direct contact with the skin. Microdroplets ejected into the air by boiling and evaporation are not a serious hazard if the operation is performed in a well-ventilated hood. Adsorption of the radioactive elements on dust, and the accumulation of this dust in the ventilating system can build up a serious situation with highly toxic, long-lived materials such as plutonium.

Centrifuging is practical provided the inside of the centrifuge bowl is painted with an acid resistant paint, and if contaminated solution from a broken tube is adequately contained.

External radiation presents no particular problem particularly if one gets in the habit of using tongs and test-tube holders instead of his fingers for handling laboratory equipment.

One should not put his hand directly over an unshielded, dry beta source even at these levels since it has been found that a Co^{60} sample adequate to give a good γ-counting rate gave a tolerance dose in $\sim$30 sec. 3'' over the counting disc. This is due to the beta radiation from the Co^{60}.

The region between 1 μc. and 1 mc. is a transition region that takes on characteristics of techniques, suitable for both higher and lower level work, so that at $\sim$100 μc. considerable judgement must be exercised. External radiation is important enough to require careful monitoring. In general, near the one mc. level one uses longer tongs, introduces semi-remote control sampling, is more careful to avoid direct exposure to unshielded beta sources, and is more careful about confining contamination.

Between 1 mc. and 1 C, massive shielding to protect against external radiation becomes important, the danger from accumulated activity and dirt is quite significant, therefore, one strives very hard to confine activity to the interior of the equipment.

A few simple procedures are presented and are followed through various ramifications.

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Of the reagents studied, none combines exclusively with uranium. For the colorimetric detection and determination of uranium, chromotropic acid and aluminon seem particularly useful, as these reagents show the greatest sensitivity for the element. Of the reagents that precipitate uranium quantitatively, for subsequent determination either by weighing or ignition of the complex, 8-hydroxy quinoline seems unexcelled, although far from being an ideal reagent.

MDDC - 1433 Comparison of the Determination of the Disintegration Rate of Radiophosphorous by Absolute Beta Counting and Colorimetric Measurement, by L. R. Zumwalt, C. V. Cannon, G. H. Jenks, W. C. Peacock and L. M. Gunning. 3 p., n.d., decl. 10/29/47. (See also Science Vol. 107 p. 47, January 9, 1948.)

A carrier-free sample of P^{32} prepared by the (n,p) reaction with S^{32} of an activity of approximately 25 millicuries was placed in the calorimeter and the energy output determined. Making a 1.3% correction for loss of beta-particle energy, which escaped the calorimeter as Bremsstrahlung, the sample measured $8.58 \pm 0.11 \times 10^{-5}$ watts at a given reference time.

A similar P^{32} sample was analyzed in a thin lens type beta ray spectrometer using a 50 $\mu gm/cm^2$ source mounting. Under these conditions the Kurie plot was straight from the maximum energy to ca. 100 kv where the absorption in the counter window could no longer be neglected. Assuming the Kurie plot to be straight below this energy, P^{32} was found to have an average energy of 0.700 Mev. This value of the average energy combined with the wattage determined calorimetrically gave a disintegration rate of $7.73 \pm 0.10 \times 10^8$ d/s at the reference time.

Absolute beta counts were made of eight different aliquots of the P^{32} solution. A 1.3% correction for backscattering from the 2.5 mg/cm^2 polystyrene film on which the P^{32} aliquots were mounted for beta counting, was made. The determinations showed a standard deviation of 2.1% with a value of $7.90 \pm 0.17 \times 10^8$ d/s at the reference time.

The rate of disintegration of two aliquots of the P^{32} solution was also determined by beta counting using a National Bureau of Standards RaD+E beta ray standard and following the procedure recommended by the Bureau. The two determinations gave the disintegration rates of 7.64×10^8 and 7.83×10^8 d/s, respectively, at the reference time.

The disintegration rates determined by the calorimetric method, the use of a calibrated G-M tube and the use of a National Bureau of Standards RaD+E beta-ray standard all agree within experimental uncertainty. The results indicate that using thin end-window G-M counter tubes with proper technique, the disintegration rate of P^{32} may be determined with a probable error of no more than 2 or 3%.

MDDC - 1434 Plutonium Ferri and Ferrocyanides, by H. H. Anderson. 6 p., July 1946, decl. 10/29/47. (ANL-JJK-14B-21).

Previous investigation on this type of compound was limited to work of M. Cefola, who added potassium ferrocyanide to plutonium (IV) nitrate in 1 M nitric acid and obtained a green precipitate with a solubility of 0.010-0.015 g of Pu/l. In this combination of two oxidizing and one reducing agents, it is difficult to assign any formula to the precipitate, a priori.

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MDDC - 1418 Quarterly Report, February 1947 to May 1947, edited by A. M. Brues, 202 p., June 1, 1947, decl. 11/7/47. (CH-3830).

In addition to quarterly progress reports, this document is made up of a series of papers numbered MDDC - 1418-A through MDDC - 1418-F. These papers are individually abstracted below.

MDDC - 1418-A The Effects of Single Dose X-Radiation of the Peripheral Blood Cells of Splenectomized Rats, by S. P. Stearner, L. O. Jacobson, and E. L. Simmons, 13 p., n.d., decl. 11/7/47.

The leucopenia following irradiation was equally severe in splenectomized and intact rats after exposure to 600 r. This was in spite of the presence of a leucocytosis in splenectomized animals at the time of irradiation.

Although splenectomy caused an anemia of 1-2 million erythrocytes per cu.mm.in Bartonella infected rats, irradiation did not result in a more severe anemia in these animals.

7 references.

MDDC - 1418-B The Effect of Folic Acid on the Response to the Peripheral Blood of the Rat to Strontium^{89}, by S. P. Stearner and L. O. Jacobson, 18 p., n.d., decl. 11/7/47.

Folic acid had no effect on the macrocytic anemia that followed the administration of Sr^{89}. At least in the case of radioactive strontium, the injury is probably exerted directly on the bone marrow and is not caused indirectly by any damage to the gastro-intestinal tract or to the liver. The action of folic acid has been reported to be similar to that of liver extract and it therefore should correct any deficiency resulting from radiation damage to liver or stomach and subsequent failure to form an anti-anemic factor.

Folic acid was equally ineffective in alleviating the effect of irradiating on the number of circulating leucocytes. This failure to affect the leucopenia that followed the administration of Sr^{89} does not substantiate the suggestion by Watson that folic acid may be effective as a treatment for the leucopenia following exposure to radiations.

It is concluded that folic acid is ineffective as a treatment for the hematological effects of internal radiations and probably by implication, for those of external radiations as well. Since total body irradiation is more likely to damage visceral organs, however, the latter question is being investigated.

6 references.

MDDC - 1418-C Carcinoma of the Colon in Rats Following the Feeding of Radioactive Yttrium, by H. Lisco, A. M. Brues, M. P. Finkel, and W. Grundhauser, 1 p., n.d., decl. 11/7/47.

This document is an abstract and is reproduced here in its entirety.

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Yttrium^{91}, one of the common radioactive fission products obtained in a chain reacting pile, is a pure beta-emitter with an energy of 1.5 Mev and a half life of 57 days. It is essentially not absorbed and, since the material remains longer in the colon than in any other portion of the intestinal tract, most of the damage occurred in this region.

One group of rats received a single feeding by stomach tube of from 1.0 to 6.0 millicuries of Y^{91}. Of the thirty-three animals in this group, four died with adenocarcinoma of the colon. The earliest tumor was seen at 135 days and the latest, at 506 days. Additional animals died with acute and chronic ulceration of the colon accompanied by benign and atypical hyperplasia of the mucosa.

A second group of rats was given 78 feedings of 0.46, 0.20, or 0.06 millicuries of Y^{91} per feeding over a period of three months. The total accumulated doses were 31.20, 15.60, and 4.68 millicuries, respectively. Clinically all animals appeared well during the feeding period and growth was not impaired. Six of the eight animals at the two higher levels died with carcinoma of the colon from 304 to 548 days after the first feeding. No malignancies were observed at the lowest level. However, many of these animals died with superficial ulcerative lesions of the colon.

MDDC - 1418-D Studies on the Effect of Radiations on Proteins, by D. L. Buchanan and E. S. G. Barron, 36 p., n.d., decl. 11/7/47.

Data are presented showing certain effects of ultraviolet and gamma rays on the absorption spectra of solutions of crystalline egg albumin.

The changes differ with the two types of irradiation, with variation in pH, and questionably with oxygen tension of the solution. The changes do not resemble those seen in heat, acid, or alkali denaturation.

In an arbitrary fashion the rate of change in the solutions being irradiated was shown to have the "zero order" type of rate constant, implying the rate of formation of product to be independent of the concentration of solute within the limits of concentration studied, but giving no information as to the actual reaction rate.

17 references.

AECD - 1418-E The Effect of Ultraviolet Light and Gamm Radiation on the Electrophoretic Properties of Egg Albumin, by D. L. Bu hanan, B. Gasvoda, and E. S. G. Barron, 26 p., n.d., decl. 11/7/47.

Electrophoretic analyses of crystalline egg albumin treated with ultraviolet rays at three different pH values are compared with the patterns obtained by treatment with heat, strong base, and hydrogen peroxide.

The results indicate a fundamental difference between the response with ultraviolet irradiation as compared with the other agents.

The electrophoretic changes seen after irradiation are modified by the pH of the solution being irradiated.

7 references.

MDDC - 1418-F **Effects of a Single Lethal Intravenous Dose of Strontium Chloride on the Plasma of a Goat, by D. L. Buchanan, B. Gasvoda, and E. S. G. Barron, 6 p., n.d., decl. 11/7/47.**

Electrophoretic patterns of the plasma of a goat before and after the intravenous injection of a lethal dose of radioactive strontium are presented.

Changes seen are a moderate decrease in albumin, α_2 globulin, and γ globulin.

5 references.

MDDC - 1419 Neutron Adsorption in Samarium, by A. J. Dempster. 2 p.,September 4, 1947, decl. 11/5/47. (ANL-AJD-193).

In a recent paper it was shown that the samarium isotope at mass 149 is reduced in abundance and that the one at mass 150 increased by long exposure to neutrons. As the alterations observed in those experiments were not very large, a 4 mg sample was exposed in a thin layer of approximately 1 mg per sq. cm. for a long time to a much stronger neutron flux.

The isotope at mass 149 was expected to be reduced in abundance to a fraction of a percent and it did not appear on the photographs.

The intensity of the isotope at mass 150 was greatly increased so that it appeared approximately equal to the one at 154. A faint gadolinium impurity showed on the long exposures, but the two absorbing isotopes at 155 and 157 were absent. The abundances of the samarium isotopes were measured with a microphotometer. The densities at masses 147, 148, 152, and 154 fell on a normal straight photographic density curve as in the previous measurements, indicating no observable absorption in these isotopes. Using these abundances as standards, the new abundance at mass 150 was found from four spectra to have a mean value of 21.2 ± 0.4 percent. The normal abundance at 150 is 7.47, and at 149, 13.84 percent, the sum being 21.3 percent; showing that within the experimental error the isotopes that disappear at mass 149 reappear at mass 150. It was estimated that absorbing cross sections of the other isotopes must be less than one percent of that of the isotope at mass 149.

MDDC - 1420 "Shielded Contact" Grounding Key for Electrometers, by G. Failla. 5 p., n.d., decl. 11/10/47.

"Kicks" at the instant of breaking contact are largely due to surface charges on the insulators near the point of contact. They can be avoided by shielding the point of contact. Design and operation are discussed.

A diagram of the design is appended.

MDDC - 1421 90 Mev Neutron-Proton Scattering Angular Distribution, by J. Hadley, C. Leith, H. York. 4 p., October 8, 1947, decl. 10/29/47. (BP-136) (See also Physical Review Vol. 73 p. 541, March 1, 1948.)

This document is an abstract and the complete text is reproduced below.

The angular distribution of protons in neutron-proton scattering has been measured for angles between 5° and 55° from the direction of the incident neutron beam. The average neutron energy for these measurements was 90 Mev produced by the stripping of 190 Mev deuterons in a 1/2-inch Be target in the 184-inch frequency modulated cyclotron.

Thin paraffin scatterers of known carbon and hydrogen content were used; the number of protons originating in neutron-carbon reactions was determined by using pure carbon scatterers.

The scattered protons were detected in a telescope of four proportional counters used in coincidence and set at a constant distance from the scatterer but at variable angle with the neutron beam. Between

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the scatterers and counters were placed copper absorbers whose thickness varied with the angle from the beam, so that only protons scattered by neutrons with energies greater than 66 Mev were counted.

It was found that in the center of mass system the ratio of proton intensity per unit solid angle for perpendicular compared to forward scattering is 0.3. This forward proton peak is expected on the basis of exchange scattering.

MDDC - 1422 Abundance of the Samarium Isotopes, by M. G. Inghram, D. C. Hess, Jr., and R. J. Hayden. 3 p., September 5, 1947, decl. 11/5/47. (ANL-AJD-198) (See also Physical Review Vol. 73 p. 180, January 15, 1948.)

Measurements were made using electrometric recording of the ion currents. This eliminates the difficulties in determining the density curves so that the isotopic abundances determined are independent of any other measurements. The analysis was made with a Nier type mass spectrograph with a 60°, six inch radius of curvature, in the same manner as previously published measurements of lanthanum and cerium. The ions were produced by heating the oxide of samarium on a tungsten filament. Ion currents were measured with a vibrating read electrometer connected to a Brown Electronik Strip Chart Recorder. No source magnet was used and the ion beams were swept across the final collector by changing the analyzer magnetic field. All discriminations are believed to be below 1%.

The following upper limits for possible samarium isotopes of neighboring masses were obtained: 140, 141, 142, less than 0.001%; 143, 145, 146, less than 0.002%; 151, less than 0.02%; 153 and 155, less than 0.01%; 156, 157, and 158, less than 0.002%; and 159, less than 0.001%.

7 references.

MDDC - 1423-A The Relative Effectiveness of Fast Neutrons and Gamma Rays in Producing Somatic Mutation in Drosophila, by G. Lefevre, 4 p., n.d., decl. 10/29/47. (See Genetics, Vol. 33, p. 112-113, January 1948.)

Wild-type male, eosin male, and eosin female larvae were exposed to various doses of hard gamma rays and fission neutrons about 26 hours after egg laying. The incidence of induced white and light eye color mosaics was determined upon emergence of the adults.

Fast neutrons appear to be at least equal to, if not more, effective than gamma rays in producing mosaics, but whether or not these are entirely due to somatic mutation cannot be decided without more extensive data.

MDDC - 1423-B The Relative Effectiveness of Fast Neutrons and Gamma Rays in Producing Somatic Crossing-Over in Drosophila, by G. Lefevre, 3 p., n.d., decl. 10/29/47. (See also Genetics, Vol. 33, p. 113, January 1948.)

Heterozygous white and eosin-white female larvae were exposed to various doses of hard gamma rays and fission neutrons about 26 hours after egg laying.

The experiments showed that neutrons are apparently much more effective than gamma rays in causing somatic crossing-over. A neutron dose equivalent to 438 r at 6 1/4 r per minute shows a mosaic incidence equal to that found after exposure to gamma rays at 1,250 r at 30 r per minute. Either a number of ionizations are required for each effective hit, or neutrons are much more likely than gamma rays to make both hits with the same ionizing particle.

Serious question is thrown on the validity of the use of mosaic size as a criterion for the estimation of the number of primordial cells present at the time of irradiation.

MDDC - 1424 Water Boiler, by Los Alamos Laboratories. 4 p., n.d., decl. 10/27/47, (LADC-442).

The water boiler is essentially a chain reacting "pile". The main function of the instrument is the mass production of neutrons. A salt of uranium 235 is dissolved in water and placed in a spherical container which is surrounded by a neutron reflector. The operation is the same as that of ordinary piles.

The instrument can also be used to produce quantities of artifically radioactive elements.

A diagram of the instrument is included.

MDDC - 1425 Absolute Cross Section for the Reaction $C^{12}(p,pn)C^{11}$ at High Energy, by E. M. McMillan and R. D. Miller, 3 p., September 30, 1947, decl. 10/29/47. (BP-128). (See also Physical Review, Vol. 73, p. 80-81, January 1, 1948.)

Recent measurements by Chupp and McMillan have shown that the cross section for producing C^{11} from C^{12} by proton impact is independent of energy from 60 Mev up to at least 140 Mev; to find the absolute cross section for this process, it was only necessary to measure the activity produced in carbon by a known current.

The apparatus used and measurements made are discussed. The activity and current measurements are combined to get the activation cross section. Two runs with values of σ_a = 0.069 barn and 0.068 barn respectively are obtained. Allowing for possible systematic errors, the result is given as 0.069 + 0.007 barn.

From the area and position of the 1-inch hole and the theoretical energy and angle distribution, the total proton current is estimated to be about 1/40 microampere, which agrees with the theoretical proton yield of 2 per cent and the estimated deuteron current of about 1 microampere.

The relative yields per atom of C^{11} from C, N(Be_3N_2), and O(BeO) samples bombarded simultaneously in a 60-Mev proton beam, were in the ratio C:N:O = 1:0.28:0.36.

MDDC - 1426 On the Binding Energy of the Triton, by M. G. Mayer and R. G. Sachs, 3 p., July 1947, decl. 10/28/47. (See also Physical Review, Vol. 73, p. 185, January 15, 1948.)

It has previously been shown that the measured magnetic moment of the triton can be accounted for without reference to meson exchange currents in the nucleus if the wave function of the ground state of the nucleus is assumed to contain a large admixture of ^2P and ^4P functions.

The binding energy of triton is calculated, taking into account the possibility that the wave function might be of that form.

From the results obtained it may be concluded that the tensor interaction will not introduce a large amount of ^2P or ^4P function into the ground-state wave function of the triton. The introduction of exchange forces would seem to strengthen this conclusion since repulsive potentials would thereby be introduced for the P functions.

MDDC - 1427 Ion-Exchange as a Separations Method. IV. A Theoretical Analysis of the Column Separations Process, by S. W. Mayer and E. R. Tompkins, 33 p., n.d., decl. 8/12/47. (See also Journal of the American Chemical Society, Vol. 69, p. 2866-2874, November 1947.)

This paper describes a simple theoretical analysis of the ion exchange column separations process for the case in which the distribution coefficient of the solute between the solid and liquid phases remains constant throughout the column. The theory is based on the assumption that the column may be considered as consisting of a number of theoretical plates of equal volume. This assumption is nearly valid for cases in which conditions throughout the column remain constant and the rate of flow does not vary. The concentration of the solutes in the eluate must not change if the theory is to hold when applied to the separations of solutes by elution from the top of the column with complexing agents.

The application of this theory to the rare earth separations is demonstrated. The elution curves derived from the theory fit the observed data within the limits of experimental error. The theory is also applied to determine the purities of the rare earths separated by this process. The general applicability of the theory to processes of this type is discussed.

MDDC - 1428 Apparatus for Measuring Young's Modulus and Decrement of Graphite and Metals, by J. W. Michener and J. S. Handloser, 19 p., n.d., decl. 11/5/47. (ANL-HDY-280).

An apparatus used for the determination of the decrement and Young's Modulus of various solid materials is described. It is essentially an impedance bridge for measuring the AC resistance between the two electrodes of a quartz bar, to which is glued a specimen of the material under test of length adjusted to half wave length at the resonant frequency of the crystal. The Young's Modulus may be found from a measurement of the resonant frequency of the composite oscillator. The decrement is then obtained from the determination of the two frequencies at which the AC resistance of the crystal is twice the resonance value.

The apparatus and its operation are described in detail, special attention being given to the features limiting the accuracy of the measurements. Circuit and block diagrams are given. The basic unit

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consists of the AC impedance bridge and its associated Wagner ground. The power for the bridge is supplied by a variable frequency oscillator and its amplifier. Two methods of measuring output bridge voltage are offered, a tuned amplifier and heterodyne oscillator and an untuned amplifier coupled to a Ballantine vacuum tube voltmeter. The frequency measurement system is composed of a Millen standard oscillator, a multivibrator and mixer, a speaker, and a Conn Chromatic Stroboscobe. The overall accuracy of the apparatus is large enough for the type of measurements made.

A series method of measuring the resonant frequency and the decrement of the composite oscillator, which involves the measurement of the current through the crystal at certain frequencies near resonance is mentioned. The decrement measurements to the date of this report have been unsatisfactory.

MDDC - 1429 Crystal Structure of Element 43, Technicium, by R. C. L. Mooney. 1 p., n.d., decl. 10/20/47. (ANL-FWHZ-126). (See also Physical Review Vol. 73 p. 653 March 15, 1948.

This document is an abstract and the complete text is reproduced below. For complete paper see MDDC - 1520.

The chemical properties of the element of nuclear charge 43, now named technicium, - were studied in 1937 from a sample made by cyclotron bombardment of molybdenum. Many activities exist, including a long-lived isotope probably of mass 99, which is also formed by fission. A sample containing this long-lived isotope was prepared for an attempt at an X-ray crystal analysis of the compounds of this element.

The purpose of the present note is to give the crystal structure of the pure element itself, which was prepared in metallic form in microgram amounts.

Like rhenium, osmium, ruthenium and a number of other elements, technicium has been found to crystallize in the hexagonal close packed arrangement.

The cell, which contains two atoms, has the following dimensions:

$a = 2.738 \pm 0.003$ A $\qquad\qquad$ $c = 4.393 \pm 0.006$ A

Each atom has twelve nearest neighbors, six at 2.706 A, and six at 2.738 A.

The density, assuming the atomic weight to be 99, is calculated to be 11.46 gm/cm^3.

3 references.

MDDC - 1430 Production and Properties of a Long-Lived Radioisotope of Element 43, by E. E. Motta, G. E. Boyd, and Q. V. Larson, 3 p., n.d., decl. 10/30/47. (See also Physical Review, Vol. 72, p. 1270, December 15, 1947.)

Since the 67 h Mo^{99} parent of Tc^{99} may be formed in appreciable yield by neutron irradiation of stable Mo^{98}, it was decided to attempt to produce the ground-state activity by irradiating quantities of pure Mo metal with neutrons from the Clinton pile.

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Four forty-gram molybdenum metal samples were irradiated for approximately one month each. After chemical separation from the metal matrix in which it was produced, the Tc activity was purified, coprecipitated with PtS_2 carrier, mounted, and counted. A typical aluminum absorption curve obtained with the sample placed at 30 per cent geometry with respect to a thin mica end-window Geiger Muller counting tube is shown. An average half-thickness of 7.3 mg Al/cm^2 corresponding to a range of 85 mg Al/cm^2, and to a maximum beta energy of 0.32 Mev was observed. A beta:gamma counting ratio in excess of 2000 has been found, and this has been taken to indicate the absence of gamma radiation more energetic than 0.1 Mev.

A subsequent neutron irradiation of four kilograms of Mo for 112 days permitted the separation of weighable quantities of element 43. Measurements of the specific activity were conducted. The best average value for the half-life of the Tc activity obtained thus far has been 9.4×10^5 years.

A mass of 99 is proposed for this radioactive isotope of element 43.

A few qualitative observations on the macro-chemistry are included.

MDDC - 1431 Yields of Neutrons from Photo-Neutron Sources, by B. Russell, D. Sachs, A. Wattenberg and R. Fields. 14 p., September 15, 1947, decl. 11/5/47. (ANL-HDY-296) (See also Physical Review Vol. 73 p. 545-549, March 15, 1948.)

The number of neutrons emitted per second per curie from ten photo-neutron sources was determined. Absolute values of yields and cross-sections may be in error by 27%, but relative values are more reliable. The photo-disintegration cross-section for deuterium, $\sigma D\ (\gamma,n)$, is found to be 16×10^{-28} cm^2 at 2.76 Mev in agreement with Rarita & Schwinger's calculations. $\sigma Be\ (\gamma,n)$ is found to be 7×10^{-28} cm^2 at 2.76 Mev. and is greater than 9.7×10^{-28} cm^2 at 1.67 Mev. The more reliable ratios of $\sigma Be\ (\gamma,n)\ /\sigma D\ (\gamma,n)$ are found to be 0.43 at 2.76 Mev. and 0.30 at 2.50 Mev.

The curve of $\sigma Be\ (\gamma,n)$ versus energy must pass through at least one maximum and one minimum in range of 1.63 Mev. to 2.76 Mev.

The number of 2.7 Mev. photons per disintegration of Mn^{56} is estimated to be about 1%. These photons are probably due to direct transitions to the ground state from the known excited levels of Fe^{56}.

22 references.

MDDC - 1432 Organic Reagents for Uranium Analysis, by E. Ware. 26 p., August 1945, decl. 11/7/47.

A careful literature survey has been made to ascertain what organic reagents combine with uranium ions, and under what conditions.

From the many reagents reported to give reactions with uranium ions, those showing greatest promise of having value for the detection and (or) determination of that element have been selected for more detailed investigation. The results of studies on many of these reagents are contained in this report.

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MDDC - 1415 Cross Section for Powdered Graphite, by G. Arnold and V. Myers. 6 p., July 1947, decl. 11/4/47, (ANL-HDY-322).

The cross section of powdered graphite was measured with the mechanical slow neutron velocity spectrometer in order to obtain a cross section versus energy curve as a further check on theoretical curves formerly obtained by Sachs and Goldberger.

Samples of extruded and powdered graphite were analysed for crystal orientation by X-ray diffraction. For the extruded graphite, the hexagonal (002) planes showed preferential alignment. No preferred orientation was observed for the (002) planes for the powdered graphite, nor for the (100) planes in either case.

Cross section vs. energy curves for randomly or nearly randomly oriented aluminum crystals were obtained in an attempt to understand the large value of the cross section near the (222) plane reflection. The various types of aluminum samples tried, all yielded similar curves. Analysis of these indicates that the large cross section is due to the reflection from the (113) plane with some small contribution from the (400) planes. It also indicates that the principal orientation in the drawn aluminum rods analysed is that in which the (113) axis is oriented parallel to the rod axis.

MDDC - 1416 The Effect of X-Ray on Mortality, Weight, Length, and Counts of Erythrocytes and Hematopoietic Cells in Fingerling Chinook Salmon, Oncorhynchus Tschawytscha Walbaum, by K. Bonham, L. R. Donaldson, R. F. Foster, A. D. Welander and A. H. Seymour. 27 p., October 29, 1946, decl. 10/31/47, (UWFL-3a)

Eight groups of fingerling chinook salmon, Oncorhynchus tschawytscha Walbaum, were subjected to different doses of X-ray graduated from 100 r to 5000 r and another group was used as a control. The lowest exposure level at which irradiated groups were significantly adversely affected 12 weeks after exposure were, for mortality 250 r, for weight 500 r, and for length 1000 r. Group means when tested against the mean of all 9 groups combined showed significant decline in regard to number of cells in the circulating blood at exposures of 750 r and 1250 r 2 and 3 weeks after irradiation, and in regard to concentration of hematopoietic cells in the kidney at 750 r level 1 and 2 weeks after irradiation.

MDDC - 1417 The Halides of Neptunium, by L. Brewer, LeR. Bromley, P. Gilles, and N. Lofgren. 18 p.,September 19, 1947, decl. 10/29/47, (BC-85).

The thermodynamic data for the ions of neptunium are given from which the heats of formation of the neptunium halides are obtained. Using these, the regions of stability of the halides were calculated. The calculations indicate that NpF_6 and $NpCl_5$ are the stable halides of highest oxidation number. $NpBr_4$ is the highest bromide which is stable. In the iodide system, only NpI_3 is stable.

Calculations based on the thermodynamic data of this report were checked against the observed chemical behavior and the excellent checks lend confidence to the use of these data for calculations on unexplored regions.

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However, upon completion of the present work, it appears that Cefola prepared what was essentially $HPuFe(CN)_6$ with tervalent plutonium and ferrocyanide.

Plutonyl nitrate solution and ferricyanide give a reddish-brown precipitate comparable in color to uranyl ferricyanide; the formula is probably $(PuO_2)_3[Fe(CN)_6]_2$. Plutonyl nitrate is reduced instantly by ferrocyanide, with formation of a black precipitate.

Plutonium (IV) chloride solution and ferricyanide give a black precipitate having a Pu to Fe ratio corresponding quite closely to plutonium (IV) ferrocyanide, $Pu_3[Fe(CN)_6]_4$. Plutonium (IV) chloride solution and ferrocyanide give a black precipitate having a Pu to Fe ratio corresponding quite closely to plutonium (IV) ferrocyanide, $PuFe(CN)_6$.

Plutonium (III) chloride solution and ferricyanide give a black precipitate of very low solubility having a Pu to Fe ratio corresponding fairly well to the expected plutonium (III) ferricyanide, $PuFe(CN)_6$. Plutonium (III) chloride solution and ferrocyanide give a light-blue precipitate of very low solubility, in which the equal ratio Pu to Fe suggests the formula H(or K) $PuFe(CN)_6$.

These compounds all adsorb solution greatly and are probably amorphous. Solubilities have been measured.

MDDC - 1435 A Comparison of the Gravimetric and Volumetric Determinations of Free UO_2 in Uranium Dioxide, by S. H. Anonsen, R. W. Bragdon, C. L. French and G. L. Martin. 8 p., June 1947, decl. 11/16/47.

An investigation was made to explain the discrepancies in results between the gravimetric and volumetric assay methods for free UO_2 in brown oxide of uranium. Ignition at temperatures in the range of 600° to 800°C indicated that the correct temperature for conversion to black oxide was about 675°C, but analysis of the ignited black oxide residues showed that the 800°C ignition product contained a nearly perfect ratio of UO_3 to UO_2.

Analysis of the brown oxide for water by the Karl Fisher reagent method showed the presence of sufficient water in the product to account for the low ignition assay for free UO_2.

The ignition assay of brown oxide for free UO_2 is subject to error due to the tendency of the powdered material to adsorb moisture. This method is recommended for use only where speed is more important than accuracy. The volumetric method of assay is recommended for an accurate determination.

5 references.

MDDC 1436 Preliminary Comparison of Radon-Boron and Ra + Be Neutrons Sources, by J. Ashkin, S. Bernstein, B. Feld, H. Kubitschek, and L. Szilard. 3 p., January 19, 1943, decl. 10/27/47. (CP-412).

The intensity of a radon-boron neutron source was compared with a radium-beryllium neutron source (1 gm. Ra + 3 gm. Be). It was found that, reduced to equal gamma ray intensity, the neutron intensity of the two sources has a ratio of about 4 in favor of the radium-beryllium source, if the intensity is measured by the n-p reaction in phosphorous, fast neutron fission or integration of the thermal neutron density in a water tank.

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It was found that the radium-beryllium source excites the 25 minute period of iodine, which is due to radiative capture, two or three times as strongly as the radon-boron source, if the two sources are so normalized as to give equal fast fission counts in a uranium fission chamber. The impression is conveyed that radium-beryllium neutrons excite, in general, radiative capture more strongly than radon-boron sources.

MDDC - 1437 Neutron Distributions in Paraffin, by B. T. Feld. 3 p., February 24, 1944, decl. 11/6/47. (CP-1389).

Preliminary results are given of the data on the indium resonance and thermal distributions for Ra-α-Be, Ra-α-B, Ra-γ-Be, Ra-γ-D sources.

The number of neutrons emitted by a "pure γ-ray source" were determined. A 2 gm. Ra source (sealed in a brass container) was placed at the center of the paraffin pile and the area under the activity x r^2 curve for thermal neutrons was obtained. By comparing this area with that for a previously standardized Ra-Be source it was found that the Ra source emits 7×10^3 neutrons per sec. This result may be in error by as much as 30% because of the extremely small foil activities, and because of the existing uncertainty in all neutron source calibrations.

To help interpret the 2.4 min Al^{28} activity found in Jesse and Spatz' water experiments, the authors tried to produce this activity by irradiating Al with fast neutrons.

Preliminary results indicate that the cross-section for Al^{27} (n,γ) Al^{28} for neutrons of several Mev (Ra-B unmoderated) is not greater than that for Al^{27} (np) Mg^{27} ($\approx 10^{-26}$ cm^2).

MDDC - 1438 Neutrons Emitted by a Radium-Beryllium Photosource, by B. Feld and E. Fermi. 3 p., n.d., decl. 11/5/47.

An account is given of experiments performed at Columbia University in November 1941 on certain properties of the photoneutrons emitted by beryllium irradiated with gamma rays from radium.

The slowing down of the photoneutrons in graphite was investigated by taking activity measurements of indium detectors inside a graphite pile in which the source was included and the slowing down properties were expressed in terms of a two range formula. Also the number of neutrons emitted by the photosource was measured by comparison with a Ra-Be source of known intensity.

The number of photo-neutrons emitted by one gram of beryllium at a distance of 1 cm. from one gram of radium is 30000 per second.

MDDC - 1439 Medical and Biological Research Activities of the Los Alamos Laboratory, by W. Langham. 20 p., n.d., decl. 10/29/47. (LADC-449).

Emphasis is being placed on using $carbon^{14}$ to trace physiological processes in animals and to trace the activities of cells and their relation to their substrate or environment.

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A number of important compounds have been tagged with carbon^{14}, namely nicotinic and p-aminobenzoic acids. Tracer studies with these tagged vitamins may help to explain why body cells occasionally become cancerous when exposed to atomic radiations.

Other growth promoting substances to be studied or in the process of study with carbon^{14} are the hormones.

A major part of the research is directed to the study of direct biological effects of atomic radiations. Radioactive phosphorus is being used to study the rate of breakdown of nucleoproteins and nucleic acids as a result of large doses of ionization radiations.

The effects of the radiations on the weight and gross appearance of the spleen, kidneys, ovary, adrenal gland, intestinal tract, bone marrow and peripheral blood are being studied. The effects of the radiations on the mitotic index (an indication of the rate of growth and replacement) of the various organs and tissues are being studied also.

Other research activities include further studies of the effects of plutonium on the animal system and of health hazards created by this material and other materials peculiar to the Los Alamos Laboratory.

12 photographs taken in the laboratory are appended.

MDDC - 1440 Phosgene Detector, by A. R. Nichols, Jr., and N. B. Garden. 20 p., n.d., decl. 10/31/47. (BC-9).

This article outlines the steps taken in solving the problems encountered in the development of a device to give rapid detection and to sound an alarm within one minute or less after phosgene gas becomes present in concentration greater than the lethal amount (considered between two and five parts per million). The method employed was to use a moving paper impregnated with a suitable dye and by means of a photoelectric cell detect the color change due to phosgene. A curve from actual operation is given showing successful performance in the region desired, with indications that such a device could be used to detect concentrations below one part per million.

A diagram of the apparatus is included.

MDDC - 1441 Recoil Protons in the Neutron Beam of the 184-Inch Cyclotron, by W. M. Powell. 1 p., October 17, 1947, decl. 11/4/47. (BP-143) (See also Physical Review Vol. 73 p. 540-541, March 1, 1948.)

This document is an abstract and the complete text is reproduced below.

A well collimated beam of neutrons from a half inch beryllium target in the 195 Mev deuteron beam of the 184-inch cyclotron is allowed to pass through a Wilson cloud chamber. The beam enters the chamber through a 5 mil aluminum window. The chamber contains a half atmosphere of hydrogen as well as alcohol and water vapors and is in a magnetic field of 13,000 gauss.

Measurements have been made of the angle and energy of recoil of the protons arising in the gas of the chamber. Curves will be given showing the distribution of the protons with angle. Comparisons of these results with similar data obtained from carbon and paraffin with proportional counters will be made.

MDDC - 1442 Crystal Structure Studies of Chlorides, Bromides and Iodides of Plutonium and Neptunium, by W. H. Zachariasen. 19 p., n.d., decl. 10/29/47. (ANL-AJK-14B-27).

Complete crystal structures have been found for the compounds $PuCl_3$, $NpCl_3$, $NpBr_3$, $PuBr_3$, PuI_3, NpI_3, PuOCl, PuOBr, PuOI, and $NpCl_4$.

$PuCl_3$, $NpCl_3$, and $NpBr_3$ are hexagonal with the UCl_3-type of structure in which each metal atom is bonded to nine halogen atoms.

$PuBr_3$, PuI_3, and NpI_3 are orthorhombic and isomorphous. The structure is of layer lattice type with each metal atom bonded to eight halogen atoms.

PuOCl, PuOBr, and PuOI all have the PbFCl-type of structure.

$NpCl_4$ is isomorphous with UCl_4.

Only the lattice dimensions and the positions of the metal atoms have been found for the compound Cs_2 $PuCl_6$.

X-ray diffraction patterns have been obtained for $PuCl_3$-H_2O, $PuCl_3 \cdot 6H_2O$, $PuBr_3 \cdot 6H_2O$, $NpBr_4$, $NpOBr_2$, and $NpOCl_2$, but the writer has not succeeded in analyzing these patterns.

The crystal structure determinations were carried with the aid of powder diffraction patterns obtained with samples ranging in weight from a few micrograms in some instances ($NpCl_3$, $NpCl_4$) to a hundred micrograms in others. All the x-ray diffraction patterns were taken with CuK-radiation filtered through nickel foil. Because of the health hazard all plutonium and neptunium preparations were in sealed glass capillaries. These were of pyrex or quartz glass with a wall thickness of about 20μ.

When a plutonium or neptunium preparation was submitted for x-ray study the chemical identity was as a rule unknown. One of the important purposes of the x-ray diffraction examination was the identification of the phase or phases in the sample. Thus, of the compounds specifically mentioned above all but $PuBr_3$, Cs_2PuCl_6, $PuCl_3 \cdot H_2O$ were first identified by the x-ray diffraction method and a knowledge of how the samples had been prepared. The chemical formulas of $PuBr_3$, Cs_2PuCl_6, $PuCl_3 \cdot H_2O$ were first deduced from direct chemical analysis.

MDDC - 1443 Initial Performance of a 32 Mev Proton Linear Accelerator, by L. W. Alvarez, H. Bradner, H. Gordon, L. C. Marshall, F. Oppenheimer, W. K. H. Panofsky, C. Richman, R. Serber, C. Turner, and J. R. Woodyard. 1 p., October 21, 1947, decl. 11/5/47. (BP-148) (See also Science Vol. 106, p. 506, November 28, 1947.)

This document is an abstract and the complete text is reproduced below.

A beam of 32 Mev protons has been produced by the accelerator. Four Mev protons from a Van de Graaff generator are injected into a resonant cavity operating at about 200 megacycles, and driven by 23 oscillators delivering a total of 1.5 megawatts peak power. The beam is phase stable and is focused radially by the action of grids of tungsten wires. Absorption measurements show the beam to have an energy of 32$\pm$.5 Mev, in agreement with that predicted from the mechanical design.

MDDC - 1444 Linear Accelerator Oscillator and Coupling System, by W. R. Baker, J. V. Franck, and J. D. Gow. 1 p., October 24, 1947, decl. 11/14/47. (BP-152) (See also Physical Review Vol. 73, p. 535, March 1, 1948.)

This document is an abstract and the complete text is reproduced below.

An oscillator capable of delivering 150 K. W. of 200 MC radio frequency power into the high "Q" resonant load of the linear accelerator has been developed. This oscillator, using four GL-434A triodes in parallel, is operated with a pulse length of 300 microseconds and a pulse repetition rate of 15 c.p.s. The operating frequency is controlled primarily by the linear accelerator cavity. A 50 ohm co-axial transmission line approximately one wavelength long and essentially unity coupled to the oscillator, operates with a voltage standing wave ratio of about 7 to supply power to the coupling loop in the linear accelerator. A resistor is placed across the transmission line at a voltage minimum for the fundamental frequency to suppress the unwanted 170 MC and 260 MC modes of the oscillator. This resistor absorbs less than three per cent of the power in the fundamental frequency. The oscillator has been designed to have optimum grid drive at high power level and so requires pre-excitation to obtain short-build-up time. No problem is encountered in phasing 24 oscillators which automatically lock into the resonant frequency of the cavity.

MDDC - 1445 Physical Design of the Berkeley Linear Accelerator, by H. Bradner, R. Crawford, H. Gordon, J. R. Woodyard. 1 p., October 24, 1947, decl. 11/14/47. (BP-154) (See also Physical Review, Vol. 73, p. 534-535, March 1, 1948.)

This document is an abstract and the complete text is reproduced below.

Thirty-two megavolt protons have been obtained from a resonant cavity linear accelerator. The cavity is a 12-sided copper cylinder approximately 40 feet long and 38" diameter, operating at 202.5mc in the TM_{010} mode which has a Q of about 70,000 and shunt impedance of 480 megohms. Protons are injected on the axis and accelerated in the gaps between 46 "drift tubes". These tubes range in diameter from 4.75" to 2.75" and in length from 4.4" to 10.9", and in center-to-center distance from 5.43" to 14.5". Tube dimensions were chosen to maintain the resonant frequency of the cavity constant throughout its length. Tungsten wire grids are used for focusing. Drift tubes are supported by conducting stems which permit accurate adjustment of drift tube position. Peak power of 1.5 megawatts is supplied by 24 triode oscillators through 24 transmission lines terminating in low-inductance loops inside the cavity. The cavity is supported in a steel tank which is evacuated at a working pressure of 10^{-5} mm mercury. Both the vacuum tank and the resonant cavity split longitudinally for access.

MDDC - 1446 Scattering of High Energy Neutrons, by A. Bratenahl, R. H. Hildebrand, and B. J. Moyer. 1 p., October 24, 1947, decl. 11/14/47. (BP-149) (See also Physical Review Vol. 73, p. 540, March 1, 1948.)

This document is an abstract and the complete text is reproduced below.

Data will be presented showing the angular distribution of neutrons scattered from spheres of various unclassified materials which are placed in the high energy neutron beam of the University of California 184-inch cyclotron. The scattered neutrons are detected by the activity they produce in carbon blocks (by the $C^{12}(n, 2n)C^{11}$ reaction). From the counting rates and the positions of the carbon detectors one obtains a curve of intensity vs. angle for each material tested. These curves will be compared with the diffraction patterns expected if one assumes the nuclear radii which have been obtained from total cross-section measurements in the 184-inch cyclotron neutron beam using similar detectors. The angular distributions thus far obtained from copper and lead agree roughly with the predicted distributions.

MDDC - 1447 The Use of Ion-Exchangers to Effect Separation, Concentration and Purification of Small Amounts of Ions, With Particular Reference to the Fission Products, by W. E. Cohn, G. W. Parker, and E. R. Tompkins. 26 p., n.d., decl. 11/12/47.

Ion-exchange procedures are described for separating, concentrating, purifying and metathesizing radioactive cationic fission products to recover them in forms and purities suitable for biological or other experimentation. The essential steps are: 1) Adsorption at the top of an ion-exchange column, 2) Elution of each species separately by complex formation, 3) Readsorption, following complex destruction by simple acidification, on smaller columns, 4) Purification from radioactive and stable contaminates and elution in the desired solvent by suitable choice of reagents and one or more recyclings on the smaller columns. Application of the method, of which examples are given, has yielded

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100-1000 mc amounts of the major fission species in radiochemical purities of >95-98% and associated with <1-5 mg of total solids, whereas the original solutions contained on the order of 100 times this amount.

A diagram of a remotely-controlled, shielded ion-exchange apparatus for curie-level separations is included.

MDDC - 1448 Crushing Strength of Aluminum Tubes, by E. Creutz. 8 p., September 17, 1943, decl. 11/19/47.

Some measurements were made by the Armour Research Foundation on the crushing strength of a series of 2S aluminum tubes, of nearly identical final hardness, specially prepared by the Wolverine Tube Division. The method of measuring the crushing strength consisted of mounting the tubes in a special pressure vessel through the walls of which the ends of the specimen extended so that atmospheric pressure was always inside the tube. The tubes were 6 1/2 inches long, making all but the 1-inch diameter tubes fall into the definition of long tubes. Since the data obtained did not fit already existing equations for steel tubes, the following empirical equation was developed:

$$P = 1.52 \times 10^7 (\log_{10}\frac{D^3}{W^3} - 2.95)\frac{W^3}{D^3}$$

where W is the wall thickness and D the tube diameter, both in inches. The observed collapsing pressure P and that calculated from the formula agree for tubes from 0.2 to 1 inch in diameter with wall thicknesses from 2% to 8% of the diameter with a root mean square error of less than 6%. The formula breaks down for wall thickness exceeding 9% of the diameter. Tests were also made on the crushing strengths of 2S aluminum tubes of different lengths to which the pressure was applied along a linear element by means of a steel round of approximately tube diameter. Inspection of the data shows that an equation of the form

$$F = \frac{KW^2}{D}$$

is followed well within the accuracy of the results. F is the force per linear inch. K for the crushing strength is 4.7×10^4 pounds per square inch. A table is given listing diameter of the tube, its wall thickness, length, load sufficient to reach the elastic limit, and ultimate load sustained. There is some indication of a decrease in strength with an increase in length. The observed values fit the empirical equation with a r.m.s. error of less than 10%.

MDDC - 1449 The Effects of Pile Bombardment on Uncured Elastomers, by W. L. Davidson and G. Geib, 14 p., n.d., decl. 11/12/47.

In the past, several workers have studied the effects of ionizing radiations on hydrocarbons. Through analysis of the products formed they have established that four competitive processes are usually operative. They include: (1) Dehydrogenation, (2) Condensation or polymerization, (3) Hydrogenation (Action of nascent hydrogen on any unsaturated matter present, (4) Decomposition (C-C cleavage).

The chain reacting nuclear pile offers an ideal means for subjecting relatively thick samples of matter (such as rubber) to uniformly high concentrations of radiation. If process (2) should predominate in pile irradiation of rubber, it is possible that a new method of vulcanization would be

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available. If process (1) proved to be controlling it would be a means of introducing unsaturation into materials such as polyisobutylene, polyvinyl chloride, acrylates, etc., thus making them vulcanizable.

Though of lesser interest, if reaction (4) turned out to be most important, it could conceivably uncover an improved method for reclaiming rubber.

The conclusions reached are as follows: (1) Uncured natural rubber undergoes polymerization and/or cross-linking when exposed to pile radiations (γ-rays, neutrons), (2) Polyisobutylene samples are appreciably degraded by pile radiation, (3) The same effects as found in (1) and (2) are greatly enhanced by secondary alpha particles, produced by an (n,α) reaction on boron (milled into the elastomers). However, even a 2 hour bombardment of natural rubber does not give a "cure" that even remotely compares with sulfur vulcanization, (4) The unsaturation present in natural rubber is slightly reduced by pile radiations and alpha particles, (5) Pile bombardment does not introduce unsaturation into polyisobutylene, (6) A typical butyl stock is permanently degraded by pile irradiation. Such a sample, on being cured, shows greatly reduced tensile strength compared to that of a control sample, and (7) Natural rubber shows a weak but measurable radioactivity days after bombardment, probably due to its mineral content. Polyisobutylene is not appreciably active.

MDDC - 1450 Effects of Small Daily Doses of Fast Neutrons on Mice, by T. C. Evans. 66 p., n.d., decl. 11/13/47.

Daily doses of 0.014 "N" of fast neutrons (0.07 "N"/wk), equivalent to 0.1 r/day of x-rays (on the basis of relative effects of single exposures), had no definite effect on mice treated for approximately 87 weeks.

Some effects (though still not pronounced) were observed in animals exposed daily to 0.07 "N", with a total dose of approximately 30 "N".

Daily exposures of 0.14 "N" (total of 60 "N") definitely reduced survival time slightly, reduced growth activity of hemopoietic organs and gonads, and slightly increased the frequency of cataracts.

Doses of 1.4 "N" per day resulted in death of over 50% of the animals by about the 29th week (total "N" = approx. 200). This irradiation caused pronounced changes within a few weeks in blood counts, activity of hemopoietic organs and gonads. In addition, extreme damage to the lens was evident by the time half of the original number had died.

Daily exposures of 1.4 "N" were more effective than those of 11 r (equivalents on the basis of relative effects of single exposures). Some effects, based on total dose at time of appearance, indicated a ratio of 12-13 r = 1 "N". Effects of 1.4 "N" per day on gonads and lens were more pronounced than even this ratio, 12 r = 1 "N", would indicate.

Considering the results generally, the most important finding was that the lens was especially sensitive to the neutron radiation.

Photographs are included. 12 references.

MDDC - 1451 Ion Source Equipment for Berkeley Electrostatic Generator, by F. Fillmore, A. Hudgins, M. Jeppson. 1 p., October 24, 1947, decl.11/14/47. (BP-153) (See also Physical Review Vol. 73, p. 534, March 1, 1948.)

This document is an abstract and the complete text is reproduced below.

The ion source in this generator was designed to produce high current proton pulses 15 times per second and of 300 microseconds duration. This permits a high injection current during the on time of the linear accelerator without overloading the electrostatic generator. The protons are generated in a Zinn-type arc equipped with a differential pumping system which removes 95% of the H_2 gas escaping from the arc chamber. The protons are accelerated to 50 KW and focused into the accelerating tube through a small aperture. The differential pumping system consists of an air-cooled diffusion pump backed by a mechanical pump operating inside a small steel tank. Hydrogen pumped from the ion source discharges into this tank and is recirculated to the ion source through an oil filter and palladium leak. Power to operate the equipment is provided by two 400-cycle generators driven by the charging belt. Cold air from a heat exchanger is blown through the textolite support tubes to cool the diffusion pump and other shell equipment. Control is accomplished by small d.c. motors which are switched on and off by a selector switch in turn is operated by a nylon fishline.

MDDC - 1452 The Heat of Solution of Uranium Tetrachloride in Aqueous Perchloric Acid Solutions, by B. J. Fontana. 8 p., August 19, 1947, decl. 11/19/47. (BC-78).

The heat of solution of UCl_4 solid has been measured and found to change appreciably with changing concentration of H^+ or ionic strength. The heat of hydrolysis of U^{+4} to form UOH^{+3} is probably of the order of +11 kcal. per mole.

3 references.

MDDC - 1453 Kinetics of the Decomposition of Tri-Valent Uranium Ion in Aqueous Solution, by B. J. Fontana. 9 p., August 19, 1947, decl. 11/12/47. (BC-79).

A brief preliminary study of the rate of oxidation of tri-valent uranium ion in aqueous $HClO_4$ - $LiClO_4$ solutions (in the absence of oxygen) was made. The reaction was followed spectrophotometrically. The reaction was found to be unimolecular with respect to U^{+3} and independent of the H^+ concentration (from 0.05 to 5.0m H^+). A 16-fold increase in rate is observed, however, on increasing the ionic strength from μ = 0.5 to 5.0.

5 references.

MDDC - 1454 Determination of Water in Perfluorodimethylcyclohexanes. I. Potentiometric Titration with Karl Fischer Reagent, by J. L. Gabbard, E. S. Amis, J. H. Hamieson and T. H. McCormick. 12 p., May 22, 1947, decl. 10/23/47. (A-3668).

The water content of perfluorodimethylcyclohexanes, C_8F_{16}, was determined potentiometrically with Karl Fischer reagent. A randomly selected sample was found to contain 7±1 p.p.m. water. Measured

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quantities of water added to the samples could be recovered within ±5 p.p.m. The solubility of water in C_8F_{16} at room temperature, at 25.0 and at 60.0°C was found to be 18.9±1.7 p.p.m., 19.2±1.3 p.p.m. and 63.3±3.9 p.p.m. respectively. The precision obtained was comparable to similar measurements recorded in the literature.

The method has advantages as to speed and ease of operations but a skilled and experienced operator is needed.

Diagrams of the Karl Fischer titration apparatus and the drying, storage, and sampling apparatus are included.

MDDC - 1455 Determination of Water in Perfluorodimethylcyclohexanes. II. Absorption by Phosphorous Pentoxide, by J. L. Gabbard, E. S. Amis, A. V. Faloon, and J. C. Pierce, 11 p., May 22, 1947, decl. 10/23/47. (A-3669).

Determinations of the water content of perfluorodimethylcyclohexane, C_8F_{16}, were made using phosphorous pentoxide as an absorbent for the water. A randomly selected sample was found to contain 5.5±0.9 p.p.m. water. Measured quantities of water added directly to samples could be recovered excepting 3 p.p.m. on the average, which remained in the sample. The solubility of water in perfluorodimethylcyclohexanes at 25.0±0.1°C. was found to be 13.6±0.7 p.p.m. Comparisons are made on the phosphorous pentoxide absorption and the Karl Fischer reagent methods for the determination of water in C_8F_{16}.

From the data, it is concluded that the phosphorous pentoxide absorption method is more precise than the Karl Fischer reagent method, but the difference in solubility can not be attributed to this difference in precision.

The difference in solubility is, however, apparently inherent in the two methods with the Karl Fischer method giving a higher value by approximately 6.0 p.p.m. The phosphorous pentoxide method, while more time consuming, is more reliable and gives results nearer the absolute value. The Karl Fischer reagent method is more rapid and in the hands of a skilled operator will give results adequate for routine control purposes.

See MDDC - 1454 for the Karl Fischer reagent method.

MDDC 1456 Physical Properties of Chlorotrifluoroethlene Polymers as a Function of Molecular Weight. I. Molecular Weight of Chlorotrifluoroethylene Polymer, by J. L. Gabbard, E. S. Amis, V. E. Anderson and R. L. Cooley. 12 p., May 22, 1947, decl. 10/22/47. (A-3655).

The molecular weight of a randomly selected lot of chlorotrifluoroethylene polymer was determined by the ebulliometric method with both benzene and carbon tetrachloride as solvents. The modified Menzies-Wright molecular weight apparatus was used for the molecular weight measurements in solutions up to thirteen weight percent of the polymer and the modified Cottrell apparatus was used for the molecular weight determinations in the more concentrated solutions.

These molecular weight values, when plotted vs. the weight percent of the polymer in solution, give a curve somewhat S-shaped which can be divided into three distinct sections.

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The part of the curve averaging the data for the molecular weight values in concentrations less than 10 weight percent is exponential. The equation representing this part of the curve is $M = A^w + 845$, where M is the molecular weight of the polymer, w is weight percent of the polymer, and A is a constant and is equal to 1.447.

The curve for concentrations of the polymer above 10 weight percent shows the molecular weight to increase directly with increased weight percent. The equation for the molecular weights along this section of the curve is $M = 10w + 783$.

At approximately 55 weight percent of the polymer the curve averaging the molecular weight data is slightly curved and the data from 55 to 65.8 weight percent, the maximum concentration investigated, fall reasonably well along a second straight line. The equation for the molecular weights along this section of the curve is $M = 4.545\ w + 1089$.

The assumed correct molecular weight of the randomly selected lot of the polymer is the extrapolated value determined at zero concentration of the polymer in benzene and is 846 ± 5 molecular weight units.

The variation of the molecular weight of the polymer in benzene solutions as a function of concentration are attributed to differences in internal pressures and polarities of solute and solvent.

MDDC - 1457 Ion Exchange as a Separations Method. II. Separations of Several Rare Earths of the Cerium Group (La, Ce, Pr and Nd), by D. H. Harris and Edward R. Tompkins. 44 p., n.d., decl. 2/10/47. (See also Journal of the American Chemical Society, Vol. 69, p. 2792-2800, November 1947.)

The separation of several rare earths of the cerium group has been accomplished by a process in which they are selectively eluted from a column of high capacity cation-exchanger with solutions of a complexing agent at various hydrogen ion concentrations. Specifically, neodymium, praseodymium, cerium and lanthanum have been separated in purities of greater than 99.9% and in high total yields, from mixtures of these elements, by the use of citric acid-ammonium citrate buffers. The optimum pH's for the separations were found to be 1) Nd and Pr - pH $\sim$2.85; 2) Pr and Ce - pH $\sim$3.00; 3) Ce and La - pH $\sim$3.6. In order that the separation be at an optimum, the maximum quantity of rare earth which could be separated was about 1-2g per cm^2 of column area, or about 10-20g per liter of column bed volume.

This separation results from the competition of the complexing agent and the ion exchanger for the rare earth ions. The dissociation constants of the rare earth citrate complexes vary considerably and thus as they are eluted down the column from the narrow band at the top, where they are originally adsorbed, they tend to separate into distinct bands and to be eluted separately. The extent of overlap of the elution curves of the adjacent rare earths varies with the conditions of elution.

MDDC - 1458 Excitation Function of the Reaction $C^{12}(p,pn)\ C^{11}$ at High Energies, by W. Heckrotte and P. Wolff. 5 p., November 3, 1947, decl. 11/20/47. (UCRL-7). (See also Physical Review Vol. 73, p. 264-265, February 1, 1948.)

The excitation curve for the reaction $C^{12}(p,pn)\ C^{11}$ at high energies has been measured. Using the model of the nucleus described by Serber, the excitation curve of the above reaction has been calculated for energies up to 100 Mev.

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The reaction can go in four ways:

(a) $p + C^{12} \rightarrow N^{*13}$; $N^{*13} \rightarrow C^{11} + p + n$

(b) $p + C^{12} \rightarrow C^{*12} + p$; $C^{*12} \rightarrow C^{11} + p$

(c) $p + C^{12} \rightarrow N^{*12} + n$; $N^{*12} \rightarrow C^{11} + p$

(d) $p + C^{12} \rightarrow C^{11} + p + n$ (knock out).

The part played by each of these separate reactions to give the total reaction is shown in diagram for 50 percent exchange.

The total reaction for both 50 percent and 100 percent exchange is plotted on a range scale diagram assuming 140-Mev protons incident on a carbon block.

The calculated cross section for the reaction at 62 Mev is: 0.049 barns for 50 percent exchange and 0.064 barns for 100 percent exchange. The experimental value is 0.067 ± 0.007 barns for 62-Mev incident protons.

MDDC - 1459 Excitation of Na^{24} and Na^{22} by Deuteron and Alpha Bombardment of Al, by A. C. Helmholz and J. M. Peterson. 2 p., October 29, 1946, decl. 11/19/47, (BP-137) (See also Physical Review, Vol. 73, p. 541, March 1, 1948.)

This document is an abstract and the complete text is reproduced below.

Using essentially the technique of Thornton and Senseman, the yield of Na^{24} and Na^{22} as a function of the bombarding energy of deuterons and alpha particles has been studied. The bombarded element was Al. After the decay of periods of a few minutes, half-life measurements identified to the 14.8 hr. period of Na^{24} and a long period which chemistry showed to be Na (almost certainly Na^{22}). The energy of the incident deuterons was 190 Mev with a spread of about ± 5 Mev; of the alphas, 380 Mev with a spread of ± 10 Mev.

With deuterons, the Na^{24} activity as a function of distance from the end of the range rises rapidly to a maximum, falls to about half the maximum, and then remains essentially constant to the highest deuteron energy. The background effects of high energy neutrons are troublesome, and no accurate method of separating them out has been found. For deuteron induced Na^{22}, the activity rises to a maximum, then stays rather constant to highest energy. With alpha-particle excitation the Na^{22} activity shows a steady drop from the maximum, while the Na^{22} curve stays rather constant to highest energy as in the deuteron case.

In the case of Al (d,αp) Na^{24} the values can be connected with those of Clark at low energies, but the spread in deuteron energy in this case makes any conclusions questionable.

MDDC - 1460 Mass Spectrometric Study of Fission Element 43, by M. G. Inghram, D. C. Hess Jr., and R. J. Hayden. 4 p., September 3, 1947, decl. 11/13/47. (ANL-AJD-208). (See also Physical Review, Vol. 72, p. 1269-1270, December 15, 1947).

A sample of element 43 (Tc) separated from uranium fission products was analyzed by a mass spectrometer in order to determine which of the possible fission isotopes have long lives. The existence

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of a 43^{99} isotope of half-life > 40 years was first predicted by Seaborg and Segre. Glendenin, working with fission products, set the half-life of a long-lived fission isotope of element 43 at > 3,000 years. A long-lived 43 activity was found in fission by Lincoln and Sullivan, and by Schuman. Motta, Boyd and Larson obtained a half-life of 9.4×10^5 years with a sample prepared by neutron bombardment of molybdenum.

The sample of fission technetium used for this work was distilled into the ionization chamber of a Nier-type spectrometer as NH_4TeO_4. The resolved ion currents were recorded by means of a vibrating reed electrometer and a Leeds and Northrup Speedomax recorder. The curves obtained in the Te^+ ion position are shown. These results show that the technetium formed in fission contains a long-lived isotope at mass 99, and that all other possible long-lived fission isotopes of technetium are present to less than 3% of this value. Making use of the fission yield curve, the authors conclude that at least 97% of the Tc^{101} nuclei formed in fission decay with a half-life shorter than six months.

MDDC - 1461 Theoretical Considerations Concerning the D + D Reactions, by E. J. Konopinski and E. Teller. 21 p., n.d., decl. 11/19/47. (LADC-447) (See also Physical Review Vol. 73, p. 822-830, April 15, 1948.)

Some possibilities are explored for the theoretical explanation of the angular distribution of D + D reaction products. The variation with energy is ascribed entirely to difference in the centrifugal barriers encountered by the bombarding particles responsible for the isotropic and non-isotropic components. The detailed data on the proton distributions at low energies appears to be explained in terms of an asymmetric part produced by P-waves superposed on isotropic emission due to S-waves. However, ordinary extrapolation of this to higher energies gives much less symmetric distributions than experimentally found at such energies for the emission of neutrons. If the experiments are correct as interpreted, then they appear to show that spin-orbit coupling plays a large part in the reactions. In that case, an isotropic component produced by incoming P-waves grows in importance with energy and accounts for the increasingly parallel growth of the isotropic and asymmetric emissions.

MDDC - 1462 Tables of Free Energy Functions for Elements and Compounds in the Temperature Range 2000° - 5000° K., by W. M. Latimer, 12 p., September 10, 1947, decl. 11/13/47. (BC-81).

Tables are given summarizing $\frac{\Delta F - \Delta H^\circ_0}{T}$ values for the elements H, B, C, N, O, F, Na, Mg, Al, Si, Cl, Ca, Ti, Zr and Fe and the compounds H_2, C_2, N_2, O_2, HF, OH, CO, MgH, NO, HCl, CN, SiN, ZrO, SiO, TiO, BO, SiF, NaCl, NH, CH, SiH, AlO, BH, AlH, MgO, and FeO, as gases, over the temperature range 2000° to 5000° K. The free energies and equilibrium constants for the dissociation of the compounds are summarized over the same temperature range. The free energy functions and equilibrium constants are also given at 2000° K for the solids MgO, CaO, TiO, and SiO_2 and for CO_2 gas at 2000° and 3000° K.

13 references.

MDDC - 1463 Absolute Cross Section for the Reaction $C^{12}(n,2n)C^{11}$ at 90 Mev, by E. M. McMillan, and H. F. York. 11 p., October 27, 1947, decl 11/20/47. (BP-156) (See also Physical Review Vol. 73, p. 262-263, February 1, 1948.)

The cross section for the reaction $C^{12}(n,2n)C^{11}$ has been evaluated by finding the activity induced by a measured flux of 90 Mev neutrons; the value found is (0.025 ± 0.005) barns.

MDDC - 1464 The Vacuum Divider; A Low Pressure Multiplier, by G. W. Monk. 9 p., n.d., decl. 10/24/47.

An instrument utilizing a 5 liter per second diffusion pump is described which allows pressures in the range 0.01 to 5 microns to be measured on a Pirani, thermocouple, McLeod or any other gage ordinarily operating in the 0.5 to 50 micron range.

A block diagram of the vacuum divider used in this experimental work is included.

MDDC - 1465 Fluorine Corrosion: (A) High-Temperature Attack on Metals by Fluorine and Hydrogen Fluoride; and (B) Behavior of Insulated Steel Parts in Fluorine Cells, by W. R. Myers and W. B. Delong. 21 p., n.d., decl. 11/13/47.

Corrosion tests at elevated temperature showed that nickel and Monel have good resistance to fluorine up to 500°C. Silicon in plain carbon steel has a marked effect on its corrosion by fluorine; steel containing 0.22% Si is unsuitable at 200°C., while that containing 0.007% Si is useful up to 350°C. The stainless steels, with the exception of type 347, show little attack up to 250°C., aluminum up to 450°C., and magnesium up to 300°C., copper, nickel, and the nickel-base alloys show reasonably good resistance to HF up to 600°C The addition of steam to HF is practically without effect on the corrosion of nickel and Monel at 600°C. The anodic corrosion of steel in $KHF_2 \cdot HF$ at 90°C. increases rapidly with potential drops above approximately 5v.

MDDC - 1466 The B-3 Beta Counter (Revised), by H. G. Neil, 15 p., August 6, 1945, decl. 11/3/47.

This is a report on the operation, construction, and servicing of a semi-portable A.C. operated beta counter. Features of the instrument are its high stability, its maneuverable probe with directional properties, its high frequency response, and its ease of operation.

A photograph and circuit diagrams of the instrument are included.

MDDC - 1467 Control of the Field Distribution in the Linear Accelerator Cavity, by W. K. H. Panofsky, C. Richman, F. Oppenheimer. 1 p., October 23, 1947, decl. 11/14/47. (BP-150) (See also Physical Review Vol. 73, p. 535, March 1, 1948)

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The cavity of the 40 feet linear accelerator consists of a long cylindrical pipe loaded with "drift tubes" of graduated lengths. Such a system has a spectrum of resonant modes near the desired operating mode, which is the mode giving uniform peripheral magnetic flux-density as a function of the axial co-ordinate. The spectrum becomes more closely spaced as the length increases. Analysis of the field-equations in the cavity has shown that the critical problem is not the problem of preventing jumping of the frequency from the proper mode to the next mode, but is the problem of controlling the uniformity of field distribution in the proper mode. This problem has been analyzed by means of simple perturbation theory. This method results in a simple procedure of adjusting the distribution using a Fourier analysis of the magnetic field distribution at the edge of the cavity. The procedure has been used experimentally with satisfactory results. The mechanical tolerances of the accelerator cavity and the problems associated with multiple cavity coupling can be studied by this method.

MDDC - 1468 Slow Neutron Velocity Spectrometer Studies of H, D, F, Mg, S, Si and Quartz, by L. J. Rainwater, W. W. Havens, Jr., J. R. Dunning, C. S. Wu. 22 p., August 28, 1947, decl. 11/4/47. (A-3974). (See also Physical Review Vol. 73, p. 733-741, April 1, 1948.)

The neutron proton cross section has been measured using a paraffin sample. The observed free proton cross section is (20.6 ± 1). The cross section curve below .05 e.v. is well matched by a theoretical curve and approaches 4 times the free proton cross section at very low energies. The thermal cross section of D_2O is well matched by the curve $^{\sigma}D_2O = (10 + 0.72E^{-\frac{1}{2}})$. The free cross section of D is(3.3 ± 0.2). The thermal cross section of fluorine in a fluorocarbon oil is well matched by the curve $^{\sigma}F$ $(3.3 + 0.11\ E^{-\frac{1}{2}})$. The cross section of the free fluorine is (3.3 ± 0.5). The cross section of Mg is essentially constant at (3.4 ± 0.1) e.v. No resonances are observed in Mg. Microcrystalline interference effects are noticed in the low energy region. The thermal cross section of sulphur is well matched by the curve $\sigma = (1 + 0.098\ E^{-\frac{1}{2}})$. No resonances are observed in S. The cross section of Si is essentially constant at (2.25 ± 0.1). No resonances are observed in Si. Microcrystalline interference effects are noticed in the low energy region. The effective neutron cross section of an optical quartz crystal decreases from the additive cross section of (9.2 ± 0.2) at ∼ 10 e.v. to 1.25 at 0.025 e.v. which is taken to be the residual incoherent cross section.

44 references.

MDDC - 1469 Statistical Error in Transmission Measurements, by M. E. Rose and M. M. Shapiro, 1 p., n.d., decl. 11/13/47.

This document is an abstract and is reproduced below in its entirety.

In certain exponential absorption experiments it is important to achieve minimum statistical error in a limited time, or to minimize the counting time required to measure the absorption coefficient with a preassigned accuracy. The conditions required to attain these ends, i.e., the geometry for optimum transmission, and the optimum apportionment of counting times among the incident and transmitted beams and background have been investigated for a wide range of relative backgrounds (10^{-3} to 10^{2}), and for two geometries: (1) Beam area fixed, absorber thickness alone is varied; (2) Beam area and absorber thickness are both disposable parameters, while the total amount of absorber intercepting the beam remains fixed. In both cases the flux density and background rate are assumed constant.

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The optimum transmissions are shown to be, in general, considerably smaller than those commonly used in absorption experiments. Thus, for case (1), a useful rule is to employ a transmission of about 0.1 for low backgrounds, 0.2 for moderate background, and 0.3 for high backgrounds.

The following have also been determined: (a) minimum statistical error for a given total counting time; (b) statistical error and the best distribution of counting times for non-optimum geometry; (c) sensitivity of the accuracy or total counting time to deviations from optimum transmission.

MDDC - 1470 Beam Dynamics in the Linear Accelerator, by R. Serber. 1 p., October 24, 1947, decl. 11/14/47. (BP-155). (See also Physical Review Vol. 73, p. 535, March 1, 1948.)

This document is an abstract and the complete text is reproduced below.

The orbits of particles in the linear accelerator are stable, both for displacements in phase and for radial displacements from the axis of the machine. Stability in the latter case is achieved by the use of grids or foils in the drift tubes. The lengths, L, of the drift tubes form a linear progression, $L\ l_1 n$. For small displacements, the frequency of phase oscillation is $\nu = (\cot \phi_s / 2\pi\ n)^{\frac{1}{2}}$, where ϕ_s is the synchronous phase, and the amplitude of oscillation is $A \sim (n^{3-2} \zeta \cot \phi_s)^{\frac{1}{4}}$. Here ζ is a number which depends on the shape of the field in the accelerating gaps ($\zeta < 0.2$ in the present machine). For the radial oscillations, $\nu = (\frac{1}{2}\pi)(K/n)^{\frac{1}{2}}$ and $A \sim (n/K)^{\frac{1}{4}}$ where K is a number of order one which depends on field shape. Multiple scattering in the foils would cause the beam to spread to a diameter d; $d^2 = [(32\ \pi\ NtZ^2e^2/KE^2)\ \ln\ (4\ \pi\ NtZ^4/3\hbar^2/m^2\ v^2)]\ [(n/n_1)^{\frac{1}{2}} - 1]$. Here t is the thickness of a foil, E is the mean accelerating electric field, and n_1 is the number of the first drift tube. If a is the internal diameter of a drift tube, the fraction of the beam transmitted is $I/I_0 = 1.6 \exp \left\{ - 1.45\ d^2/a^2 \right\}$.

MDDC - 1471 The Application of $Li^6(n,\alpha)$ and $B^{10}(n,\alpha)$ to Slow-Neutron Monitoring, by M. M. Shapiro and J. R. Barnes. 1 p., August 20, 1947, decl. 11/13/47.

This document is an abstract and the complete text is reproduced below.

When slow neutrons impinge on a photographic emulsion impregnated with lithium or boron, the yield of disintegration tracts from the $Li^3(n, \alpha)$ and $B^{10}(n, \alpha)$ reactions, respectively, is very high. Moreover, when a suitable emulsion is employed, the tracks are dense and easily observable under high power magnification. These observations suggested the applicability of the Li and B reactions to slow-neutron health monitoring. Further investigation showed that this method of monitoring is more sensitive by several orders of magnitude than the $N^{14}(n, p)$ reaction currently employed. For example, in the Li-loaded plates the yield of tracks from a given slow-neutron flux is about 150 times the yield of the $N^{14}(n,p)$ tracks. Furthermore, each track (produced by a triton and an alpha particle recoiling in opposite directions) is ten times as long as, and considerably denser than, the proton track from nitrogen. Therefore, it is easier to recognize and count. With boron-loaded emulsions, the alpha-particle tracks are even more numerous, although shorter than the tracks from Li. Either of these proposed techniques of slow-neutron health monitoring permits higher accuracy, while reducing enormously the time and labor consumed in microscopic counting of tracks.

MDDC - 1472 An Ion Source for Isotopic Mass Comparisons, by A. E. Shaw, 1 p., October 22, 1947, decl. 11/19/47. (ANL-AJD-205).

This document is an abstract and the complete text is reproduced below.

In a previous paper, a source of positive ions was described in which solid samples were heated in a tungsten crucible to a high temperature by electron bombardment. Further experiments have shown that a fraction of the bombarding electrons may be used to ionize neutral atoms as they leave the crucible. Ionized atoms with all charges up to six have been observed with 500 volts electrons. This source is suitable for comparing the masses of the isotopes of the heavy elements with those of the light elements for which more accurate masses are known. Preliminary observations have been made with a double focusing mass spectrograph on the doublet, Cu^{+1} - Pt^{+3}, at mass 65. Uranium ions with four charges appear at the equivalent mass 59.5 and have been compared with the nickel masses. Platinum with six charges can be compared with the oxygen molecule of mass 32; and platinum with five charges with potassium 39.

MDDC - 1473 The Ionic Absorption Spectra of the Uranium Halides in a Polar, Non-Aqueous Solvent, by C. C. Sterett and V. P. Calkins, 17 p., April 7, 1947, decl. 11/10/47.

The absorption spectra of various uranium halides have been measured in methyl acetate, the following halides of uranium being used; the trichloride, tribromide, tetrachloride, tetrabromide, monobromotrichloride, pentachloride, hexachloride, tetravalent oxychloride and the hexavalent oxychloride. All these halides but the tetravalent oxychloride were found to be soluble in methyl acetate.

Only two distinct spectra were exhibited by these halides. The uranyl chloride gave an absorption spectra characteristic of the uranyl ion whereas all the other soluble halides gave an absorption spectra characteristic of the tetravalent uranium ion. Mechanisms for these reactions have been proposed.

MDDC - 1474 The Berkeley 4 Million Volt Electrostatic Generator, by C. Turner, B. Cork, J. Ballam, and H. Gordon. 1 p., October 24, 1947, decl. 11/14/47. (BP-151).

This document is an abstract and the complete text is reproduced below.

The Berkeley pressure Van de Graaff machine was designed to inject 4 Mev protons into the linear accelerator. The Wisconsin horizontal design was extrapolated to insure dependable operation at 4 million volts. The pressure tank is 8 feet inside diameter, with a maximum operating pressure of 200 p.s.i.g. The 20" air gap between high potential electrode and tank is divided into two 10" gaps by a second shell operating at half the total voltage. The length of the insulating column is 15 feet. The high potential electrode is 54" O.D. and 6 feet long to provide space for extensive equipment for operation of a high current pulsed ion source. Provision was made for two accelerating tubes - one for the proton beam and one for an electron beam to be used for voltage control. Reasonably dependable operation at 4 million volts has been attained with 100 p.s.i.g. nitrogen pressure and about 40 pounds of freon. Proton beams of several microamperes have been obtained, but results are very preliminary.

MDDC - 1475 Changes in the Thresholds of Gas Flow Beta Counters, by R. W. Cole. 17 p., October 3, 1946, decl. 11/20/47.

The threshold of a gas flow beta counter can change with the flow rate because of air diffusing into the counter through small leaks. Data are presented showing how the threshold depends on the flow rate, the size of the air leak, and the time since flow stopped.

Water vapor passing through the window can also change the threshold of the counter. The permeability of various materials to water vapor was determined.

MDDC - 1476 Photoelectrons for Space-Charge Neutralization, by S. C. Curran, 25 p., April 25, 1945, decl. 11/6/47. (RL 16.6.78)

In report MDDC - 1477 preliminary results obtained in investigations of the possibility of using are sources of high ultra violet efficiency for the production of high intensity currents of photoelectrons were discussed. The effects of thus making the liner walls into virtual sources of electron current were examined with particular attention being paid to the phenomena of beam oscillations. At the same time, results of experiments designed with a view of clarifying the physics of the light source and its photo-action on various materials were given briefly. This report amplifies some of the results discussed previously and gives new data on other aspects of the problem.

MDDC - 1477 The Use of Photoelectrons for Space-Charge Neutralization, by S. C. Curran, 17 p., January 26, 1945, decl. 11/4/47. (RL 16.6.75).

The problem of neutralization of the positive space charge produced by a beam of positive ions is one of fundamental importance. It is generally the case that the beam produces sufficient electrons by collision processes in the residual tank gas or by bombarding the wall of the tank and thus producing secondary electrons. However, at very low tank pressures such as 3 μa Phillips Ion Gage current the electrons produced in the gas may prove insufficient and likewise wall conditions may be such as to reduce to an unstable level the amount of secondary emission. In these circumstances there is a tendency for high frequency oscillations to appear in the beam, as viewed on an oscilloscope. These oscillations are sufficient in many cases to destroy the definition of the beam. Thus, means of producing additional electrons in the path of the beam are important. It has been shown that it is possible to produce sufficiently abundant supplies of photoelectrons from the wall of the tank to eliminate many of the effects associated with lack of electrons for space-charge neutralization.

MDDC - 1478 Release for Press Tours, Los Alamos, 2 p., n.d., decl. 11/20/47. (LADC-451).

The Los Alamos Scientific Laboratory was established for the purpose of conducting the necessary research to establish the practicality of an atomic weapon; and, if a weapon were shown to be possible, to produce it for military use.

Most of the research activities of the Laboratory are conducted primarily for their potential application to the problem of nuclear energy and military weapons. However, many of the fundamental processes which go into a bomb also bear upon the construction of devices in which nuclear energy is released at a controlled and useful rate.

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The Los Alamos Laboratory maintains for the Atomic Energy Commission the specific responsibility for the nation's supply of atomic weapons. This responsibility includes certain production and fabrication activities actually carried on at Los Alamos, as well as the specification, procurement, and acceptance of the many other components which go to make up an atomic bomb.

MDDC 1479 Remarks on University Affiliations and Laboratory Facilities, Los Alamos, 10 p., n.d., decl. 10/27/47. (LADC-444).

A general paper describing the research facilities for graduate students.

MDDC - 1480 The Lethal Action of X Radiation, Stable Isotopes of Fission Elements, Sr^{89}, and (Ba - La)^{140} Upon Goldfish, by C. L. Prosser, C. W. Hagen, Jr., and W. Grundhauser. 38 p., July, 1947, decl. 11/20/47. (ANL-4017).

Solutions of stable barium at 1 ppm killed 50 per cent of goldfish within 30 days. Cerium was toxic at 10 ppm, and bromine, at 1000 ppm. Solutions of strontium and iodine were nontoxic, at least up to 1000 ppm.

Single doses of 850 r X radiation killed 50 per cent of goldfish within 30 days. Half a group of goldfish receiving 100 r daily were dead at 26 days; half a group at 50 r daily were dead at 33 days; whereas half the controls and those receiving 25 r daily were dead at 40 days.

Calculations of radiation dosage show that in solutions containing fission products at 1 μc/ml, the dose due to external radiation is a small fraction in comparison with that due to internal radiation. In solutions of Sr^{89} at an initial concentration of 0.1 μc/ml, deaths were no more frequent than among controls. At an initial concentration of 0.4 μc/ml, however, a significant number of deaths occurred. On the basis of measurements of accumulated Sr^{89}, the median total accumulated dose of internal beta radiation varied from 1,580 to 27,550 rep at daily (24 hour) rates of 50 to 680 rep. Lethal doses for goldfish in aquaria in which Sr^{89} was replenished monthly were similar to those given in a single dosage. This similarity was also observed for lethal doses in single experiment with (Ba-La)^{140}.

MDDC - 1481 The Preparation and Some Properties of UBr_3, UBr_4, $UOBr_2$, and UO_2Br_2, by F. H. Spedding, A. S. Newton, R. Nottorf, J. Powell, and V. Calkins. 41 p., n.d., decl. 11/5/47.

An investigation of the preparation and some of the physical properties of UBr_3, UBr_4, $UOBr_2$, and UO_2Br_2 has been carried out in order to study methods of preparing UBr_3 and UBr_4. Uranium tribromide has been prepared by the action of hydrogen bromide on uranium hydride and by the reduction of uranium tetrabromide with hydrogen. Its density was 5.98 26°/4. The solubility of UBr_3 on various organic and inorganic solvents has been studied.

Uranium tetrabromide has been prepared by several methods, the most useful of which were 1) the action of bromine on uranium tribromide followed by distillation using bromine in nitrogen as a carrier gas, and 2) the direct synthesis from uranium metal turnings in a quartz apparatus using bromine carried in helium gas to form the tetrabromide and distill it in one operation. The density of

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uranium tetrabromide has been found to be 5.33 26°/4, the melting point was 519±2°C, and the boiling point at 740 mm was 761°C. The solubility in various organic and inorganic solvents was studied. The vapor pressure of uranium tetrabromide was measured and can be expressed by the equations:

$$\text{For sublimation: } \text{Log } P_{mm} = \frac{-10{,}900}{T} + 14.56$$

$$\text{For vaporization: } \text{Log } P_{mm} = \frac{-7{,}060}{T} + 9.71$$

Δ H(sublimation) = 50,000 cal/mol
Δ H(vaporization) = 32,000 cal/mol
Δ H(fusion) = 18,000 cal/mol

A study of the uranium tetrabromide, uranium tribromide system showed a eutectic at 75 mol % UBr_4 with some evidence of solid solubility at UBr_4 concentrations above the eutectic.

Uranous oxybromide was found in the residue from the distillation of UBr_4. It has also been prepared by the action of bromide on $U_3O_2S_4$ at 600°C. It is relatively non-hygroscopic and dissolves in water to give a clear green solution. Uranyl bromide has been prepared in an impure state by the controlled oxidation of UBr_4. Both these compounds are of importance as impurities in UBr_4.

36 references.

MDDC - 1482 Ion-Exchange as a Separations Method. I. The Separation of Fission-Produced Radioisotopes, Including Individual Rare Earths, by Complexing Elution from Amberlite Resin, by E. R. Tompkins, J. X. Khym, and W. E. Cohn, 55 p., n.d., decl. 1/15/47. (See also Journal of the American Chemical Society, Vol. 69, p. 2769-2776, November 1947.)

Experiments are described upon which is based the method which was developed in 1943-1944 for the separation of most of the major radioactive fission products, including certain rare earth species, from the mixtures in which they are found. The method was developed specifically and empirically to separate curie quantities of the major fission product radioisotopes in radiochemically and chemically pure form without resort to carrier materials, and in a form suitable for biological experimentation. The results of the study establish the applicability of this method of separations and qualitatively define the range of conditions under which the separations could be made.

MDDC - 1483 Energy Distribution of Protons From A Target Bombarded by 190 Mev Deuterons, by W. W. Chupp, Eugene Gardner, and T. B. Taylor, 25 p., October 29, 1947, decl. 12/10/47. (UCRL-2) (See also Physical Review, Vol. 73, p. 742-749, April 1, 1948.)

Previous experimental work by Helmholz, McMillan, and Sewell has shown that a narrow beam of high energy neutrons is produced when a beam of 190 Mev deuterons strikes a thin target. The mechanism for the production of the neutrons has been discussed by Serber, who describes a process in which the proton in the deuteron strikes the edge of a nucleus in the target and is stripped off, while the neutron misses and continues on its way. It is to be expected that an equal number of high energy protons are produced by stripping processes in which it is the neutron that hits the nucleus. These high energy

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protons have been detected by carbon activation, and photographic plates. Both methods give energy distributions in agreement with the energy distribution predicted for protons produced by the stripping process.

The carbon activation method is faster and more reliable than the photographic plate method.

Both methods are described at length.

MDDC - 1484 A Portable Micro-r-Meter, by G. Dessauer. 16 p., July 14, 1944, decl. 12/1/47. (II-188-7404).

The micro-r-meter described will measure intensities of the order of the tolerance doses in less than a minute with an accuracy of plus or minus 1%. The instrument is easily read, portable, does not depend on an external source of electric power, and weighs not more than twenty pounds, including its carrying case. If the tolerance dose is to be received in an 8-hour day, the average radiation amounts per second become 3.47 micro-r and .347 micro-r respectively.

The features of the meter are described at length and directions for operation are given.

Circuit diagrams and photographs of the instrument are included.

MDDC - 1485 Application of Filter Paper Partition Chromatography to the Qualitative Analysis of Volatile and Non-Volatile Organic Acids, by K. Fink and R. M. Fink. 11 p., October 28, 1947, decl. 11/13/47. (II-188-7445).

A procedure for the application of filter paper partition chromatography to the separation of both volatile and non-volatile organic acids with chain lengths of about eight carbons or less is described. The potassium hydroxamate derivatives of the organic acids are prepared by reacting the methyl ester with about a two fold excess of a mixture of potassium hydroxide and hydroxylamine in methyl alcohol. The hydroxamate derivatives obtained from about 10^{-6} mole of each of the esters are applied to the filter paper, the chromatogram developed with suitable solvents, and then sprayed with ferric chloride to make the derivatives visible as purple spots on a yellow background. Isobutyric acid and phenol gave the best results of the solvents tried for two-dimensional chromatograms of the dicarboxylic acids. R_F values for a number of hydroxamate derivatives are given for several solvents

$$R_F = \frac{\text{movement of spot}}{\text{movement of advancing front of liquid}}$$

MDDC - 1486 Radiocarbon and Filter Paper Partition Chromatography, by R. M. Fink and K. Fink, 6 p., October 27, 1947, decl. 11/13/47. (II-188-7443). (See also Science, Vol. 107, p. 253-254, March 5, 1948.)

Experiments with radioiodine, I^{131}, indicated that filter paper partition chromatography might be a very useful tool in biological studies with radioisotopes. In order to determine whether the procedure could be used profitably with radioactive elements showing a more general distribution and a less penetrating radiation, an experiment was carried out with radiocarbon, C^{14}.

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One milligram of Chlorella suspended in 0.1 ml of distilled water was exposed to light in the presence of 2 ml of air containing a few micrograms (one microcurie) of radioactive carbon dioxide for a period of four hours, and the tube containing the Chlorella was then connected with a tube containing solid KOH for an additional hour. The Chlorella suspension was divided into two equal portions, one of which was hydrolyzed in 0.1 ml of 6 N HCl for 24 hours, and the other centrifuged and extracted with 25 microliters of hot 80% alcohol for 30 minutes. A two-dimensional chromatogram of each of the solutions (plus added amino acid markers) was developed with phenol and collidine and after the filter papers were dry, they were pressed directly against sensitive X-ray film (E. K. "No Screen") for three days. The alcohol extract gave an excellent chromatogram.

The experiments appear to be convincing evidence that an extremely valuable tool for intermediary metabolism studies with radioisotopes is at hand. With the possibility of preparing filter paper chromatograms of moderately water-soluble compounds of low molecular weight, such as amino acids, sugars, organic acids, purines, peptides, and a variety of other organic and inorganic substances, a considerable amount of data concerning the metabolic fate of radioactive compounds may be obtained by a very simple procedure.

MDDC - 1487 Use of Radioactive Reagents in Filter Paper Partition Chromatography, by R. M. Fink and K. Fink, 4 p., October 28, 1947, decl. 11/13/47. (II-188-7444) (For general summary of MDDC - 1485, 1487, see Nature Vol. 160, p. 801-803, December 6, 1947.)

Filter paper partition chromatography seems destined to become an exceedingly useful and versatile micro-analytical technic for biological studies.

In experiments in which radioautographs of filter paper chromatograms were prepared in order to determine the radioactivity of various tissue constituents after administration of a radioactive compound, it developed that excellent chromatograms could be prepared with quantities of material many orders of magnitude less than those required for visible color reactions. This finding led to the idea of using radioactive reagents, rather than color reagents, for the detection of the various compounds on the filter paper, and preliminary tests have shown sufficient promise.

Suspension of the developed chromatogram in a closed vessel filled with a radioactive gas which reacted with the class of compounds under investigation gave satisfactory results. The formation of radioactive derivatives of the mixture of compounds prior to its placement on the filter paper was not satisfactory.

MDDC - 1488 The Lack of an Effect of Aging on Mutation Rate Induced by Irradiation, by E. Novitski. 4 p., September 24, 1947, decl. 12/1/47. (II-188-7348).

Some biological systems, as for instance, cells and chromosomes, possess under certain circumstances the ability to recover from injury inflicted by irradiation and it was conceded that genes might also. If this were true and if the recovery time involved a matter of days, then one might expect to find a lesser number of mutations if the animals were aged after (or during) irradiation than without such aging.

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The mutation rate was measured for sperm, in spermathecae of females, irradiated with an X-ray dose of 1000 r. Some sperm were utilized in fertilization shortly after treatment, others were aged within the females for three weeks before fertilization occurred. No difference in mutation rate was observed.

MDDC - 1489 The Transmission of Monoenergetic Slow Neutrons Through Solid Solutions and Mechanical Mixtures of TiC and WC, by S. S. Sidhu. 17 p., October 6, 1947, decl. 12/9/47, (ANL-HDY-343).

The transmission of neutrons with wavelengths comparable to the interplaner spacings in a crystalline substance have been shown to be modified by the physical state of the substance. In the present investigation the transmission of monoenergetic slow neutrons through finely powdered solid solutions and mechanical mixtures of TiC and WC was measured and the total neutron scattering cross sections determined as a function of the mole percent of WC. The measured cross sections of both the solutions and the mixtures were found to increase with increasing percent of WC. For mixtures they are practically the same as the additive cross sections (those computed from measured TiC and WC values according to the proportion in which each compound was present in the particular sample considered); each constituent scatters independently of the other. The cross sections of the solutions are lower than those of the mixtures at low percentages of WC, but increase rapidly with the concentration of the solute molecules. Since the scattering cross sections are in this way sensitive to both the structure of the solvent and the concentration of the substituting atoms, they may be used, for a given structure, as a measure of the solubility of the solute.

MDDC - 1490 The Neutron Spectrum of Boron Bombarded by Polonium-Alphas, by H. Staub. 10 p., January 11, 1944, decl. 12/4/47. (LADC-391).

The neutron spectrum from the disintegration of boron by α particles is measured using the technique of the pulse height method in a hydrogen filled ionization chamber. The spectrum shows a broad distribution probably extending to about 6 Mev with a maximum at about 3 Mev. The average neutron energy is about 2.3 Mev.

MDDC - 1491 Advancement in Industrial Radiography, by G. H. Tenney. 6 p., n.d., decl. 12/5/47. (LADC-420).

A popular survey of the development of radiography is presented. An historical account is included and some indications of techniques and accuracies at present obtained are given.

MDDC - 1492 The Influence of Irradiation for 24 Hours with Gamma Rays at Low Dosage on the Mutation Rate in Drosophila, by D. E. Uphoff and C. Stern. 16 p., September 23, 1947, decl. 12/3/47.

In order to study the effect of irradiation from radium on the sex-linked lethal mutation rate in sperm of the fly Drosophila melanogaster, females were inseminated and kept with their internally stored sperm for 20 days. During the twenty-first day the experimental flies were irradiated continuously with a total of about 50 r, while others were kept as control. A total of 46,232 offspring from irradiated individuals was tested for lethal mutations, and a total of 44,601 offspring from controls.

The rate of mutation was 0.2834 for the experimentals and 0.1682 for controls. The difference between these rates is statistically significant.

In view of the former results on chronic irradiation, as well as of the fact that the control rate of the present report is unexpectedly low, a final interpretation of these results cannot be offered. Several alternative interpretations are discussed.

MDDC - 1493 Plutonium Project Record, Volume IX-B, Papers from Chapter 8, edited by N. Sugarman, Argonne National Laboratory, 117 p., n.d., decl. 12/1/47.

This document is made up of a series of papers numbered MDDC - 1493-A through MDDC - 1493-BB. These papers are individually abstracted below.

MDDC - 1493-A Studies on the Separation of Rb, by H. B. Evans and E. R. Schuman. 6 p., n.d., decl. 12/1/47.

Several procedures for the isolation of Rb activity from fission material are presented. These are based on the removal of Cs and Rb from all other cations with $PtCl_6^=$ or ClO_4^- and application of precipitation reactions specific for either Rb or Cs for final separation of Rb from Cs. Two precipitation reagents for Rb alone, $NaHC_4H_4O_6$ and sodium 6-chloro-5-nitrotoluenesulfonate, and two precipitation reagents specific for Cs, BiI_3 in HI and silicotungstic acid have been tested.

MDDC - 1493-B A Note on the Determination of Sr as $SrCO_3$, by E. J. Hoagland. 1 p., n.d., decl. 12/1/47.

The complete text is reproduced below.

Consistent and accurate results both in standardization and analysis can be obtained by the precipitation and weighing of Sr as $SrCO_3$ rather than as $SrC_2O_4.H_2O$. Strontium carbonate was found to precipitate quantitively and is readily dried at 110°C to the anhydrous compound. Filterable precipitates are obtained by adding Na_2CO_3 slowly to the buffered Na_2CrO_4 filtrate from the Ba analysis. Results are reproducible within 1 per cent.

MDDC - 1493-C The Determination of Mo Activity in Fission, by J. B. Dial. 3 p., n.d., decl. 12/1/47.

A procedure for the isolation of Mo activity in fission material is presented. This method is based on the effective removal of insoluble hydroxides and sulfides with Pb carrier from a mixture of NH_4OH and $(NH_4)_2S$ and the precipitation of Mo with α-benzoinoxime. The time required for a single analysis is about 4 hours, and the chemical yield is 60-80 per cent.

MDDC - 1493-D Improved Determination of Mo Activity in Fission, by N. E. Ballou. 6 p., n.d., decl. 12/1/47.

An improved procedure for the isolation of radiochemically pure Mo has been developed. It is based on precipitation of Mo with α-benzoinoxime, $Fe(OH)_3$ scavengings and gravimetric determination of Mo as silver molybdate.

MDDC - 1493-E Determination of Element 43 and Ru Activities in Fission, by L. E. Glendenin. 5 p., n.d., decl. 12/1/47.

A method for the separation of element 43 and Ru from fission material and from each other is presented. The isolation of these elements is based on their oxidation to volatile compounds by fuming $HClO_4$, subsequent distillation of their oxides from $HClO_4$ into NaOH solution, reduction of Ru in the basic solution with ethanol to precipitate Ru and adsorption of element 43, which is left in solution, on Re_2S_7 precipitate. The radiochemical yield of Ru and element 43 in this procedure cannot be determined directly since the ruthenium oxide precipitate is not a satisfactory weighing form and Re is added after much of the chemistry has been performed; however, experiments with Ru and 43 tracers indicate a consistent radiochemical yield of 90±5 per cent for Ru and 80±5 per cent for element 43 under these conditions. The time required for a single analysis is 1 to 2 hours.

MDDC - 1493-F Improved Determination of Element 43 Activity in Fission, by L. E. Glendenin. 5 p., n.d., decl. 12/1/47.

An improved procedure for the radiochemical determination of element 43 activity in fission material making use of the distillation of element 43 with H_2SO_4, is presented. The radiochemical yield can be determined quite accurately; the method is simple and rapid, and it provides very effective decontamination from the other fission products, especially Ru.

MDDC - 1493-G Determination of Rh Activity in Fission, by J. A. Seiler. 2 p., n.d., decl. 12/1/47.

A procedure to separate Rh from fission material, making use of the precipitation of $K_3Rh(NO_2)_6$ with KNO_2, is presented. This method is simple and rapid, and it seems to provide adequate decontamination from Te and the other fission products.

MDDC - 1493-H Determination of Rh Activity in Fission, by N. E. Ballou. 20 p., n.d., decl. 12/1/47.

A pyridine complex of Rh has been found which is extracted by pyridine from a strongly alkaline solution. A separation of Rh from Te is effected which is better than any accomplished previously. Several other less clean Rh-Te separations are described.

Complete directions are given for a radiochemical analysis procedure which separates Rh from all the fission products and many other elements.

MDDC - 1493-I Determination of Pd Activity in Fission, by J. A. Seiler. 2 p., n.d., decl. 12/1/47.

A procedure is presented for the separation of Pd activity from the other fission products, making use of the precipitation of palladium dimethylglyoxime in slightly acid solution.

MDDC - 1493-J Determination of Pd, Cd and In Activities in Fission, by L. E. Glendenin. 6 p., n.d., decl. 12/1/47.

Brief descriptions of analytical procedures for the minor fission elements, Pd, Cd and In, are given.

The fission-produced isotopes of these elements are all formed in low yield (about 0.01 per cent) and are relatively short-lived with the exception of 43D Cd^{115} (0.0008 per cent fission yield).

The separation of Pd from other fission products is accomplished by precipitation of palladium dimethylglyoxime in dilute acid solution (HNO_3 or HCl).

The separation of Cd from other fission products is based upon precipitation of CdS with H_2S in dilute acid solution.

The separation of In from other fission products is based upon precipitation of In_2S_3 with H_2S in HAc solution.

MDDC - 1493-K Determination of Ag Activity in Fission, by T. B. Novey. 2 p., n.d., decl. 12/1/47.

A procedure for the isolation of Ag from fission material is based on repeated chloride and sulfide precipitations. The determination requires about 2 hours and gives a product of better than 99 per cent radiochemical purity. The chemical yield is 60-90 per cent, the loss coming from handling.

In the procedure described, Ag is precipitated as AgCl.

MDDC - 1493-L Determination of Sb Activity in Fission, by J. A. Seiler. 4 p., n.d., decl. 12/1/47.

A procedure is presented for the isolation of Sb activity from fission material, making use of the precipitation of Sb_2O_5 by boiling in fuming HNO_3, the subsequent distillation of Sb in the presence of CuCl and finally, the precipitation of Sb_2S_3 in neutral solution.

MDDC - 1493-M Determination of Sb Activities in Fission, by C. W. Stanley and L. E. Glendenin. 4 p., n.d., decl. 12/1/47.

A procedure to separate radiochemically pure Sb from fission material, based on the extraction of $SbCl_5$ in 10 M to 12 M acid solution with isopropyl ether, is described.

Complete interchange between the valence states of carrier and fission Sb is assured by oxidation of Sb^{III} to Sb^{V} with Br_2. Numerous precautions are taken to achieve high decontamination. The method has been successfully used on quite old fission material to isolate the long-lived Sb free of other fission activities.

MDDC - 1493-N Determination of Te Activity in Fission, by T. B. Novey. 3 p., n.d., decl. 12/1/47.

A procedure for the isolation of Te activity from fission material is presented, based on the reduction of Te to the metal by SO_2 in hot 2.6-2.9 M HCl. The determination requires about 1.5 to 2 hours, and the chemical yield is 80-90 per cent.

The procedure cannot be used to isolate Te from freshly irradiated material since Rh and Se contamination is high.

MDDC - 1493-O Improved Determination of Te Activity in Fission, by L. E. Glendenin, 6 p., n.d., decl. 12/1/47.

The procedure for the radiochemical determination of Te has been improved by the addition of a $Fe(OH)_3$ scavenging step to remove Rh. In addition, metathesis of nitrates is carried out with HBr rather than HCl. The use of HBr for metathesis has the added advantage of completely removing Se by volatilization of $SeBr_4$. Tracer tests indicate satisfactory separation from other fission activities including Rh.

MDDC - 1493-P The Preparation of Carrier-Free Te Tracer with Se Carrier, by L. E. Glendenin. 5 p., n.d., decl. 12/1/47.

A prodecure for the preparation of carrier-free Te tracer is described, making use of the co-separation of radioactive Te from fission on Se precipitated by reduction to the element with SO_2 in 3 M HCl solution and subsequent separation of Te from Se by precipitation of Se with SO_2 in 12 M HCl solution. The yield is $\sim$ 50 per cent, and the radiochemical purity of the Te tracer is > 99 per cent.

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An interesting characteristic of carrier-free Te prepared by this method is that the Te activity is in the quadrivalent state when prepared but upon standing becomes oxidized completely to the hexavalent state in a short period of time. This oxidizing effect may be due to peroxide and other decomposition products formed by action of Te β radiation on the water.

MDDC - 1493-Q Preparation of Carrier-Free Te Tracer, by L. Jacobson and R. Overstreet. 4 p., n.d., decl. 12/1/47.

A procedure is described for the preparation of large quantities of carrier-free Te tracer, making use of the co-separation of Te activity from fission material when copper and ruthenium are precipitated.

Procedures are given for preparing either Te^{IV} or Te^{VI}.

MDDC - 1493-R Determination of Iodine Activity in Fission, by G. W. Campbell and E. L. Brady. 2 p., n.d., decl. 12/1/47.

A procedure to separate iodine from fission material is described, which makes use of the oxidation of I^- carrier to I_2 with HNO_2 and the subsequent extraction of I_2 with CCl_4. The chemical yield is $\sim$ 90 per cent, and the time required for a complete analysis is $\sim$ 1.5 hours. There is no evidence of radiochemical contamination by other elements.

MDDC - 1493-S Improved Determination of Iodine Activity in Fission, by L. E. Glendenin and R. P. Metcalf. 6 p., n.d., decl. 12/1/47.

An improved procedure for the determination of I activity in fission has been developed. The procedure includes preliminary steps to assure complete interchange between active I and carrier I. A satisfactory method consists of the oxidation of I^- carrier to IO_4^- (periodate) with NaClO in alkaline solution. After the interchange reaction, the solution is acidified, the IO_4^- is reduced to I_2 with hydroxylamine hydrochloride ($NH_2OH \cdot HCl$), and the I_2 is extracted with CCl_4. The I_2 is removed from the CCl_4 by shaking with water containing $NaHSO_3$ and is then purified by another CCl_4 extraction cycle in which $NaNo_2$ is used for oxidation of I^- to I_2 and $NaHSO_3$ for reduction of I_2 to I^-. The I is finally precipitated as AgI for weighing and counting. Contamination by other fission activities including Br is negligible. The complete procedure with a discussion of development work is given.

MDDC - 1493-T The Determination of Fission Iodine from U Metal, by S. Katcoff, et al., 4 p., n.d., decl. 12/1/47.

A procedure to isolate iodine activity from irradiated U metal is presented. Complete exchange of the iodine activity with I^- carrier is assured by this method since the active I is formed in a highly reducing medium. The direct separation of I activity from other fission elements is based on CCl_4 extraction of I in the elementary state. The chemical yield is $\sim$ 60 per cent, and contamination by other fission activities is negligible.

MDDC - 1493-U A Note on the Preparation of Carrier-Free Iodine Tracer from Deuteron-Bombarded Te, by R. Overstreet and L. Jacobson. 1 p., n.d., decl. 12/1/47.

The complete text is reproduced below.

Tellurium metal is fused on a Cu target and bombarded in a bell jar with deuterons. The Te is dissolved with 6 N HNO_3, and the solution distilled. The distillate, containing the radioactive 13.0d I^{126}, 25m I^{128}, 12.6h I^{130} and 8.0d I^{131}, is collected in CCl_4, which is then washed three times with distilled water. Sufficient Cl_2 gas is added to the CCl_4 to produce a definite yellow color, and the mixture is placed in direct sunlight for at least one hour. At the end of this period, the CCl_4 mixture is extracted with an excess of either Na_2SO_3 or $Na_2S_2O_3$ to give a solution of tracer iodine free of significant amounts of inactive I carrier.

MDDC - 1493-V A Note on the Preparation of Carrier-Free Cs Tracer, by R. Overstreet and L. Jacobson. 2 p., n.d., decl. 12/1/47.

The complete text is reproduced below.

An alkaline NH_2OH filtrate, from a large sample of unseparated fission products, containing approximately 5 grams of U, Sr^{89}, Ba^{140}, La^{140} and Cs^{135} and traces of $Ru^{>104}$ and Te^{129}, is digested with aqua regia to destroy the NH_2OH. Fifty mg of $CuCl_2$ is added, and the solution is adjusted to 0.5 N HCl. The Cu and traces of Ru and Te are removed as the sulfides. The filtrate is brought to pH 2.5, and UO_4 is precipitated with H_2O_2. Inert Sr and Ba were added to the solution and removed with $(NH_4)_2CO_3$, and the NH_4Cl in the filtrate is destroyed with aqua regia. The residue is evaporated and taken up in 1 N HAc, and 50 mg NH_4Cl is added; sodium cobaltinitrite is added to precipitate the NH_4 and Cs^{135}. The precipitate is decomposed in aqua regia, and inert Sr, Y, Zr, Ru, Te, Ba, La, Ce and Th hold-back carriers are added. Fifty milligrams of NH_4Cl is added and reprecipitated with sodium cobaltinitrite as before. The precipitate is decomposed and a third precipitation made without the addition of hold-back carriers. The precipitate is again decomposed and the Co removed as CoS at pH 8-9. The filtrate is evaporated, NH_4Cl decomposed, the residue converted to the chloride, and the final solution adjusted to pH 2.6 to conform to the other preparations. Assay shows <0.5 per cent radioactive contaminants and no detectable quantities of inert hold-back carriers.

MDDC - 1493-W A Note on the Rapid Determination of Y Activity in Fission, by C. R. Dillard, R. B. Adams, H. Finston, and A. Turkevich. 2 p., n.d., decl. 12/1/47.

The complete text is reproduced below.

A rapid procedure for the determination of Y activity in fission has been developed. The method was used successfully to isolate the 20m Y activity reported by Hahn and Strassmann to be formed in U fission. In the procedure used, 25 ml of saturated UNH solution was given a 16.5 μah bombardment with paraffin-moderated neutrons. The bombardment required 20 minutes, and chemistry was begun 9 minutes after the end of irradiation. To 2 ml aliquote of the sample were added 20 mg of Y carrier and 10 mg of La, Ce and Zr. The solution was then slurried with 1.5 gm of solid $BaCO_3$ and centrifuged. This was repeated twice more to remove the U completely. The residual Ba was removed by precipitation with dilute H_2SO_4. The rare earths were then precipitated with NH_4OH. The rare-earth hydroxide precipitates were dissolved in a minimum of dilute HCl, and an excess of saturated K_2SO_4 was added. The solution was heated to precipitate the potassium lanthanum double sulfate. It was found that Ce and Zr were also removed at this point. More La carrier was added and the sulfate

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precipitation repeated. The Y which remained in solution was precipitated with oxalic acid and filtered through a filter disc. The precipitate was washed with water, alcohol and ether, mounted in the usual manner and counted. The first count was taken 74 minutes after the end of bombardment. A typical decay curve consisted of three components, the 20m Y, the 3.5h Y and the ~11h Y.

MDDC - 1493-X A Note on the Rapid Determination of Ce Activity in Fission, by R. Schuman. 2 p., n.d., decl. 12/1/47.

The complete text is reproduced below.

A more rapid method is presented for the determination of Ce activity in fission, which uses $KBrO_3$ rather than $KClO_3$ in HNO_3 as an oxidizing agent for Ce. In this procedure, Ce, La, Y and Zr carriers are added to dilute UNH solutions (~ 10 mg UO_2^{++}/ml). The solution is diluted to 10 ml; 10 ml of concentrated HNO_3 is added, and $Zr(IO_3)_4$ is precipitated by addition of 10 ml of 0.8 N HIO_3. The supernate is then oxidized with 1 gm of $KBrO_3$ (no heating is necessary), and $Ce(IO_3)_4$ precipitates as the Ce^{3+} is oxidized. The $Ce(IO_3)_4$ is dissolved in H_2O_2, a small amount of HNO_3 and water, and the cycle of $Zr(IO_3)_4$ and $Ce(IO_3)_4$ precipitation is repeated. The oxidation of Ce proceeds more rapidly with bromate than with chlorate. In addition, the danger of incomplete oxidation of Ce is removed by the use of bromate.

This procedure takes from 20 to 30 minutes, whereas the time previously required was 1 1/2 to 1 3/4 hours. A hundredfold decontamination from a mixture of Rb, Ba, Y, La, Zr, Cb and Ux activities has been observed.

MDDC - 1493-Y Separation of La from Pr and Nd by K_2CO_3, by J. A. Seiler, 4 p., n.d., decl. 12/1/47.

A method is presented for the separation of La from Pr and Nd, making use of the increasing solubility of the rare-earth potassium carbonate with increasing atomic number.

The solution of rare earths, containing 20-30 mg of La_2O_3, 10-20 mg of Pr_2O_3 and 5-20 mg of Nd_2O_3 (all as nitrates) is made alkaline with NH_4OH. The rare earths are precipitated as the hydroxides; the supernate is discarded, and the precipitate is dissolved in 1 ml dilute HNO_3. Add 4 ml 50 per cent K_2CO_3 solution; boil for one minute over a flame to expel NH_3; add 25 ml of H_2O, and boil for one minute. Remove the solution from the flame and stir vigorously for a few minutes until it becomes turbid.

Boil gently with stirring a few minutes longer to complete the precipitation. A very dense, fine, white, crystalline powder of $LaK(CO_3)_2$ is formed. Add 1-1.5 ml more of the K_2CO_3 solution, boil 2-3 minutes, remove from flame, stir 1-2 minutes longer, and centrifuge. The precipitate and supernate are treated separately: to obtain La free of Pr Nd, dissolve the precipitate in HNO_3, add 7-10 mg each of Pr and Nd, and recycle. Repeat as many times as necessary; to obtain Pr and Nd free of La, cautiously neutralize the supernate with HNO_3 to precipitate praseodymium-neodymium carbonates, centrifuge, dissolve the precipitate in 1 ml of dilute HNO_3, add 20-30 mg of La carrier, and separate the La as before. Repeat as many times as necessary.

Although the final precipitates are radiochemically pure, they are not chemically pure, so that chemical yields cannot be obtained by weighing. The spectrophotometer can be used to estimate the relative proportions of the three elements in a precipitate.

MDDC - 1493-Z The Composition of Precipitates of La Formed with Na_2CO_3, by E. R. Purchase and E. J. Young. 5 p., n.d., decl. 12/1/47.

Very little is known about the composition of rare-earth carbonates. The composition of a gelatinous sodium lanthanum carbonate precipitate, formed by addition of an aqueous solution of $LaCl_3$ to Na_2CO_3, is reported to be $3Na_2CO_3.2La_2CO_3.2OH_2O$. Zabronini and Carobbi disagree with this, reporting the formation of $Na_2CO_3.La_2CO_3.10H_2O$ by this procedure. In the course of this study two compounds, $NaLa(CO_3)_2$ and $Na_5La_3(CO_3)_7$ are identified.

The method of precipitation and analysis of these precipitates is fully described.

MDDC - 1493-AA Preparation of Carrier-Free 13.8d Pr^{143}, by B. J. Finkle and W. E. Cohn. 4 p., n.d., decl. 12/1/47.

A procedure is presented for the preparation of carrier-free Pr^{143}, which makes use of the production of 13.8d Pr^{143} by irradiation of Ce with pile neutrons. Neutron bombardment of stable Ce produces 33h Ce^{143}, which decays by β emission to 13.8d Pr^{143}. After oxidation to the quadrivalent state, Ce is removed by precipitation as iodate.

MDDC - 1493-BB Determination of UX Activity, by L. Winsberg and J. A. Seiler. 3 p., n.d., decl. 12/1/47.

A procedure is presented for the separation of UX activity from fission material. The method is simple and rapid, and it provides efficient decontamination from the fission elements.

Thorium is used as a carrier for its isotope UX. Thorium iodate, together with UX and Zr, precipitates from a concentrated HNO_3 solution on addition of HIO_3 while the other fission products including the trivalent rare earths (Ce is present in the reduced state) remain in solution. Thorium with UX is then precipitated as oxalate from a solution containing Zr hold-back carrier. Zirconium remains in solution as the soluble oxalate complex. The thorium (an UX) oxalate is ignited to the oxide and mounted.

MDDC - 1494 Comments on reported interatomic distances in fluorinated hydrocarbons, by S. H. Bauer. 29 p., March 19, 1946, decl. 12/3/47. (XAC-R-146).

The problem is presented in the form of three questions.
(a) Does substitution of two or more fluorine atoms for hydrogen atoms in $H_3C - X$ or $H_2C = Y$ compounds decrease the C - X or C = Y bond length appreciably?
(b) Is there a correlation between bond length and bond strength?
(c) Is there a correlation between bond length and reactivity, in reactions such as hydrolysis, pyrolysis, or resistance to oxidation?
It is indicated that an affirmative reply to (a) is not justified.

No clean cut evidence has been presented supporting an affirmative reply to (c). Molecular structures and reactivities for several sets of compounds will have to be determined independently, and the results compared before one could legitimately use information regarding reactivities to reduce ambiguities in the measurement of bond lengths, and vice versa.

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Sufficient data have been accumulated to give an affirmative reply to (b).

A number of references are cited and discussed.

MDDC - 1495 Low Geometry Alpha Particle Ionization Chambers, by C. J. Borkowski. 13 p., November 8, 1944, decl. 11/24/47. (CP-2026).

When solutions of high specific alpha activity are to be assayed for product it is often difficult to obtain reproducible results by diluting the solution sufficiently to remove a small volume from which a sample can be prepared and counted at "52%" geometry.

In order to assay such a solution, most reproducible results have been obtained with minimum effort in sample preparation by making use of low geometry chambers.

Two types of low geometry chambers are described: (1) The air-screen type which reduces the geometry simply by placing screens of various transparencies above the sample; and (2) The vacuum low geometry chamber which accomplished geometry reduction by increasing the distance between sample and collecting electrode thus decreasing the solid angle subtended by the sample and aperture through which the particles pass into the ionization chamber.

Because the geometry of the air screen type chamber is quite critical to sample spreading and because 12 mm sample plates are required, it has found very little use.

On the other hand, the vacuum chamber, because it is non-critical to sample spreading and especially non-critical to sample thickness, has found widespread use in product chemistry studies and high alpha activity experiments.

Photographs and drawings are included.

MDDC - 1496 The Hydrogen Isotopes—Thermodynamic Properties of Their Compounds, by T. G. Fox, 48 p., September 1942, decl. 11/25/47. (100R-91).

This paper is a collection of data of thermodynamic (plus some thermal and mechanical) properties of the hydrogen isotopes and their compounds and references thereto. The following are included:

D_2 and H_2, D_2O - HDO - H_2O, organic molecules, halogen acids, hydrogen compounds of certain metals and non-metals, ammonium salts, and deuterates and hydrates.

MDDC - 1497 Chapter I - Nuclear Physics Primer, by Hanford Engineer Works, 28 p., n.d. decl.12/4/47.

This chapter introduces the beginner to the fundamentals of nuclear physics.

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Building blocks of matter (structure of the atom, structure of the nucleus—isotopes, atomic and nuclear forces)
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Types of nuclear reactions (methods of reaction, absorption of neutrons)
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MDDC - 1498 Three-Channel Pulse Analyzer, by W. A. Higinbotham, 2 p., 1944, decl. 11/20/47. (LADC-454).

A circuit diagram for a three-channel pulse analyzer is detailed. The system is complete, having its own power supply, electronically regulated.

MDDC - 1499 Entropy, Specific Heat, etc., Data on U, UO_2 and UO_3, by K. K. Kelley, and G. E. Moore, 2 p., December 24, 1942, decl. 12/10/47. (CT-385).

This report consists of tables giving heat contents of U, UO_2, and UO_3 above 298.16°K (400°K to 1500°K) as obtained from smooth curves and from experimental results.

MDDC - 1500 Modified Cascade Impactor by S. Laskin, 7 p., n.d., decl. 12/1/47.

The report consists of several drawings that show the construction details for the building of a cascade impactor. This machine is used for the purpose of separating particles of different sizes from an air stream by passing through a series of jets followed by collection slides which act as a collecting plate for various size particles.

MDDC - 1501 Transmutation of Radium to Actinium (Ac^{227}), by S. Peterson, 5 p., July 1946, decl. 11/20/47. (ANL-JJK-14B-69).

One milligram of radium has been bombarded with pile neutrons, producing Ac^{227} corresponding to a cross section of 18-20 barns for neutron capture by Ra^{226}. The actinium was separated from the radium by a resin adsorption-elution process.

After final purification the actinium fraction showed 1.95×10^6 disintegrations per minute.

MDDC - 1502 The Clinton Walkie-Talkie and Scale of Two, by W. H. Ray. 11 p., August 1, 1946, decl. 12/1/47. (MonP-65).

The Walkie-Talkie received its name from the fact that the operator wears head phones and carries the major part of the instrument from a shoulder strap. The aluminum instrument case is 9 3/16" long, 7" high, and 3 7/8" thick. It contains the batteries and the choke coil-multivibrator high voltage

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supply. The Eck and Krebs thin wall G.M. tube filled with 85% neon, 15% ethyl ether accompanies a 1 N 5 G T vacuum tube in a probe connected to the power supply by a 3' cable. The convenience of this probe, protected by large mesh wire cloth, is the outstanding feature of this mobile Geiger-Muller detector. The overall weight of about 10 pounds makes this instrument acceptable for survey work. The major service requirement of this rugged instrument with few controls, is the replacement of the filament supply batteries. The aural detection provided by this instrument makes it extremely useful as a scanner to locate sources of beta or gamma radiation.

MDDC - 1503 Determination of Particulate Air-Borne Long-Lived Activity, by W. H. Ray, 9 p., n.d., decl. 11/21/47.

In the determination of air contamination with long-lived radioactive dusts or mists a correction must be made for the presence in the collected sample of active materials found in the atmosphere due to the natural radon and thoron content of the air.

The commonly used methods of dust collection are: electrostatic precipitation and filtering through NDRC paper. The radon and thoron decay products whose presence will affect the count of the collected dust samples are Radium A, B, C, C', and C'' and Thorium A, B, C, C', and C''. This will be true whether the air is being tested for the presence of an alpha emitter or a beta emitter.

The activity of the members of the radium chain decays rapidly. A chart is presented which shows how the count will decrease.

The rate of decay of thorium products is determined by Thorium B whose half-life is 10.6 hours. An equation of the decay curve is presented. A nomographic method for solving this equation has been devised and the nomographs and instructions for their use are appended.

MDDC - 1504 Energy Spectrum of Po-Be Neutrons, by H. T. Richards, 4 p., July 21, 1944, decl. 11/13/47. (LADC-446).

Recoil protons in photographic emulsions have been used to measure the energy distribution of the neutrons from a Po-Be source. The inferred neutron spectrum has a broad maximum and in the interval 2-4 Mev and has an average energy of about 4.1 Mev. There are a few neutrons above 10 Mev. In contrast with other earlier measurements of this spectrum, relatively few neutrons are found in the energy region below 2 Mev. The spectrum of Ra-Be sources may be roughly inferred from the present data if the different energy of the Ra alpha particles is taken into consideration.

MDDC - 1505 Plutonium Progress Record, Volume IX-B, Papers from Chapter 7, edited by N. Sugarman, Argonne National Laboratory, 36 p., n.d., decl. 11/25/47.

This report is made up of a series of papers numbered MDDC - 1505-A through MDDC - 1505-G. These papers are individually abstracted below.

MDDC - 1505-A Fission Yield of Members of Chain 141, by A. Goldstein, R. P. Schuman, and W. Rubinson, 2 p., n.d., decl. 11/25/47.

A study of the change in fission yield along the chain $\sim$1.7s Xe^{141} → short Ce^{141} → 18m Ba^{141} → 3.5h La^{141} → 28d Ce^{141} → stable Pr^{141} has been made using two different methods. In both cases a comparison was made between the 18m Ba^{141} and the 28d Ce^{141} members of the chain.

In the first of these methods, a direct fission yield determination of the 18m Ba^{141} was made and compared with the previously determined yield of the chain from a 28d Ce^{141} analysis.

Barium was isolated and counted immediately, and corrections for the presence of daughter and the 85m Ba^{139} were applied. A series of nine such determinations gave results varying from 4.15 per cent to 5.0 per cent, averaging 4.61 per cent. The yield of 28d Ce^{141} is 5.7 per cent, and the ratio of the Ba^{141} yield to this is 0.81. Because of the difficult corrections involved, this result is probably not very accurate. However, it does indicate a change of yield along the chain.

In the second method, a comparison was made between the 28d Ce^{141} produced from 18m Ba^{141} which had been isolated immediately after bombardment, with the total 28d Ce^{141} produced.

From a known fraction of bombarded UNH, Ba was immediately isolated by three concentrated HCl and two $La(OH)_3$ precipitations. The final solution was made up to a known volume, and part of it was analyzed for Ba to obtain the Ba chemical yields. Another Ba isolation was made from another fraction of the UNH in a similar manner a little after the first.

After all the Ba had decayed through La to Ce, Ce was isolated from the Ba samples by the usual Ce procedure. Also, after the 33h Ce^{143} had decayed, Ce was isolated from a known quantity of the original UNH. The Ce samples were then counted; those from the Ba were pure 28d Ce^{141} and those from the original UNH contained both 28d Ce^{141} and 275d Ce^{144}. The 28d Ce activity in the latter mixture was determined from an Al absorption curve. Corrections for chemical yield, absorption, and, in the case of the samples from Ba^{141} decay, for the decay of the 18m Ba^{141} before isolation were applied.

Comparison of activities obtained in this manner gave Ba^{141}/Ce^{141} yield ratios of 0.76, 0.74, 0.83, 0.95, and 0.85; the average being 0.82.

The errors in the Ba analysis and in the determination of the 28d Ce^{141} activity from the complex absorption curve may be considerable.

A preliminary experiment to determine the relative yields of La^{141} and Ce^{141} has also been made. The UNH was bombarded, and time was allowed for the 18m Ba^{141} to decay completely to 3.5h La^{141}. Two separate fractions of Ce-free rare earths were then isolated at two different times from the UNH by the standard chemical procedures. The La chemical yields were obtained from part of the samples. After the 33h Ce^{143} had decayed, Ce was isolated from the two La samples and from the original UNH.

Within the relatively large error of the experiment, no independent yield of Ce^{141} was found. The results indicate an independent fission yield of 3.5h La^{141} of $\sim$1.1 per cent.

MDDC - 1505-B Independent Fission Yield of 33h Ce^{143}, by R. P. Schuman, 1 p., n.d., decl. 11/25/47.

The complete text of this document is reproduced below.

A preliminary experiment has been performed to determine the independent fission yield of 33h Ce^{143} in the chain

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$\sim$ 1.3s Xe^{143} → short Cs^{143} → 1m Ba^{143} → 18m La^{143} → 33h Ce^{143} → 13.8 Pr^{143} → stable Nd^{143}

The Ce-free rare earths were isolated by the usual procedure from the original UNH at two different times. Lanthanum chemical yields were determined from part of the samples. After the 18m La^{143} and the 1.8h $Ce^{(145)}$ isotope had decayed, Ce was isolated from each La sample and from the original UNH.

Decay curves were taken so that the 28d Ce^{141} and 275d Ce^{144} contributions could be subtracted and the 13.8d Pr^{143} corrected for.

The results indicate a ratio of yields of La^{143} to Ce^{143} of $\sim$ 70 per cent with a considerable error due mainly to errors in the chemical yield determinations and the corrections from the decay curves.

MDDC - 1505-C Absence of 140d Ce^{140} in Fission, by J. A. Seiler and L. Winsberg, 2 p., n.d., decl. 11/25/47.

An upper limit of 4×10^{-4} per cent has been determined for the branching ration of the decay of 40h La^{140} to 140d Ce^{140}.

It is now thought that the 140d Ce is probably Ce^{139}, decaying by K electron capture to La^{139}.

MDDC - 1505-D Discovery of the 17.5m Pr^{144}, by A. S. Newton, A. Kant, and R. E. Hein, 7 p., n.d., decl. 11/25/47.

Separation of Pr from an old Ce sample isolated from irradiated UNH revealed the presence of a 17m Pr activity in equilibrium with the 300d Ce. The 2.7 Mev β associated with the equilibrium mixture is that of the 17m Pr, whereas the energy of the β radiation emitted by the 300d Ce is $\sim$ 0.26 Mev.

MDDC - 1505-E Gamma Radiations of the 17.5m Pr^{144}, by J. A. Seiler and L. Winsberg, 8 p., n.d., decl. 11/25/47.

A Pb absorption curve of an old Ce sample of high activity indicates the presence of two γ radiations of energies 0.22 Mev and 1.25 Mev. Both γ radiations are established as belonging to the 17.5m Pr^{144}. It is estimated that the 0.22 Mev γ is emitted in 40 per cent of the disintegrations, and the 1.25 Mev γ in 5 per cent of the disintegrations.

MDDC - 1505-F Further Study of the Long Lived Rare Earth Activity in Fission, by J. A. Seiler and L. Winsberg, 5 p., n.d., decl. 11/25/47.

A rare earth activity of $\sim$ 4y half-life was found to be present in the decay curve of a La fraction. Its β energy was $\sim$ 0.2 Mev. No γ radiations were detected. From the value of the fission yield, $\sim$ 1.3 per cent, and other chemical evidence, the activity is thought to be an isotope of Nd or 61 with a possible mass assignment of 147.

MDDC - 1505-G Study of the 47h $Sm^{(153)}$ in Fission, by L. Winsberg, 11 p., n.d., decl. 11/25/47.

The 47h Sm which can be produced by neutron activation of Sm is formed in the fission of both U and Pu. The radiations of this isotope as determined by absorption measurements are a 0.78 Mev β, a 0.1 Mev γ and a 0.57 Mev γ in low intensity. The fission yield in U^{235} is 0.15 per cent.

MDDC - 1506 Chapters 21, 22, and 23 from Battlefronts of Industry, by D. O. Woodbury, 32 p., n.d., decl. 12/12/47.

These three chapters comprise the atom bomb material in Mr. Woodbury's book, Battlefronts of Industry. The emphasis is on Westinghouse's contribution to the Manhattan Project. Chapter 21 serves as an introduction, Chapter 22 is called "Uranium", and Chapter 23 is titled "Battle of the Isotopes".

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